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SOME PROBLEMS OF FORESTRY.

BY
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So much has been written and said during the past ten or fifteen years concerning the practical benefits and the pressing need of systematic forestry in America that there are very few persons who are not more or less conversant with the subject, broadly considered. The advocates of the movement have been men of such strength of personality, and so earnest and persistent in their efforts to propagate it that their claims for it have come to be generally accepted as accurate and well established. Consequently, there is now a widespread popular belief in the desirability of a system of administration which shall conserve and replenish our wasted forests. One cannot escape the conviction, however, upon an analysis of the situation, that this popular belief rests more upon the strength of personality of the advocates of the movement than upon definite scientific demonstration of the facts. A study of the literature which has appeared during the last decade on forestry reveals much of general statement and comparatively little of data upon which the statement could be

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logically based; that is, the facts have been stated rather than demonstrated. This has given opportunity to the opponents of the movement in the United States for considerable adverse criticism, not only bringing into question the general utility of forests as a modifying agent in the regulation of stream flow and the distribution of atmospheric moisture, but also with respect to the economic features involved in the preservation and replenishment of wood supplies. In many cases there can be no doubt that this criticism has arisen among those who have been thwarted in wasteful methods of production of lumber or worse methods of procuring forest lands from the public domain. In other cases, it would seem that in fairness the opposition could not be assigned to any such axe-grinding motives. Without any attempt to further classify this criticism, for no matter what its source it can ultimately serve but one purpose,—that of more certainly establishing the truth,—I wish to consider for a part of the time at my disposal some of the general facts in the case, and to show as far as time will permit some of the data upon which their promulgation may be justified.

Let us first consider the economic side of the matter. Is the State of Pennsylvania or is the United States justified, from mere considerations of profit and loss, in using the public funds to preserve and replenish our forests? The contention of the critics here briefly stated is that the forest lands of the United States under existing methods will always prove a sufficient source of wood. It is true, they say, that we are now using more wood, several times over, than we are growing, but the rapid development of concrete and other substitutes for lumber will so decrease the demand in the next decade that the supply will always remain ample. If the money we are now expending for the preservation of forestry were to be used in experimenting with these substitutes, the solution of the problem of wood supply would be arrived at more quickly and with much greater and more lasting satisfaction. Structural timber, railroad ties, telegraph and telephone poles, cars, ships, together with a hundred other articles which have in the past been heavy in their demands upon forest products may be and even are more advantageously constructed of steel, concrete, and other alternative materials. The future will see still more rapid advances in this respect, and the contingency of an insufficient wood supply when the next

generation has arrived will have been found to be a mere bug-a-boo.

Now, as to the facts of the case. The only guide for the future in any line of action is judgment based on past experience and present facts.

The United States is using at present 23,000,000,000 cubic feet of wood per annum. This shows not only a greater aggregate consumption of lumber, but increased per capita consumption over ten years ago.

At the present rate of consumption, the supply of standing lumber in the United States, by a liberal estimate on the best available statistics, will last fifteen years or twenty years. This is in spite of the rapid development of concrete and steel construction which has been mentioned, and also in spite of a simultaneous deterioration of quality and rapid increase in price. We grow three-tenths as much lumber as we use and waste; the figures being 40 cubic feet per acre consumed, while 12 cubic feet per acre is grown. Under present administration, the production outside the government forests is decreasing and will continue to do so. Now, assuming that we shall have to depend twenty years from now upon the wood actually grown from year to year,—remembering that in the face of substitution of steel and concrete for wood the demand has increased in the past decade, and keeping in mind the many uses where wood can never be advantageously displaced by other substances,—each person is free to decide in his own mind whether a supply equal to less than three-tenths of the present demand will be sufficient. This problem is not a local one, but is world-wide. Those European countries which have gone farthest in the substitution of other structural materials for wood are importing at increasing cost large quantities of lumber. And with a single exception these countries are taking the greatest care to meet future demands by systematic forestry. Germany, France, and Austria are examples. The exception is England. She has hitherto been able to count with certainty upon outside aid from such near sources as Norway and Sweden. But even England has awakened to the grave problem involved in her future wood supply. In March, 1908, the function of the Royal Commission on Coast Erosion was enlarged so that it should inquire and report

"Whether in connection with reclaimed lands or otherwise, it is desirable to make an experiment in afforestation, and if so, by what authority and under what conditions such experiment should be conducted." The Commission reported at length on the matter in January, 1909. I should like to read portions of a summary of that report appearing in *Nature* (vol. 79, p. 359), as an expert opinion on such general phases of the matter as we are considering.

1. "The afforestation of suitable lands in the United Kingdom, if undertaken on an adequate scale and in accordance with well-recognized principles, should prove at present prices a sound and remunerative investment."

2. "In estimating the profits of sylviculture, account must moreover be taken of two facts—the increased consumption of timber per capita throughout the world, in spite of the introduction of alternative materials, and, further, the exploitation, waste, and destruction by fire of the virgin forests, especially those yielding the more important building timbers. Already a noticeable shortage of timber supply has resulted, as is evidenced by steadily rising prices and depreciating qualities in all markets. It seems impossible to escape from the conclusion that this tendency will be continued and accentuated, and that a steady and a very considerable rise in prices may be looked for throughout the present century. The security which afforestation offers for investment is therefore likely to be an improving one, with a corresponding increase in profits. But, to avoid all that is speculative, this prospect has been disregarded in framing our estimates."

The report then proceeds to outline in detail a plan for afforestating a maximum area of 9,000,000 acres, at the rate of 150,000 acres per annum.

The same journal (vol. 79, p. 371) comments on the scheme as follows: "The value of the property in possession of the State at the consummation of the plan would be £562,075,000 or £106,993,000 in excess of the sum involved in its creation, and, allowing three per cent. compound interest on the initial capital expended, the annual revenue would be £17,411,000. These figures include the purchase price of the lands and costs of planting."

In the United States, there are 168,000,000 acres of land which could be utilized for forestry by private or public agency without economic loss. Using the figures of the Royal Commission as a basis this area would at the expiration of eighty years be yielding to the United States Government or its citizens the enormous sum of one and a half billions of dollars. This does not take into consideration the enormous benefits to subsidiary enterprises which depend upon the forests for their raw material.

I would like to show you some of the economic results forestry has achieved in European countries where it is practiced most scientifically.

TABLE 1.—EXPENDITURES AND REVENUES OF NATIONAL FORESTS, SHOWING HIGHER PRODUCTIVENESS UNDER LARGER EXPENDITURES.[1]

Country.	Total net revenue from Government forests.	Expenditure per acre.	Net revenue per acre.
Württemberg	$ 3,098,428	$2.05	$6.60
Saxony	2,299,000	3.00	5.30
Baden	829,162	3.58	4.42
Hesse	744,209	1.25	4.29
Switzerland	237,663	1.32	2.55
Prussia	17,054,144	1.58	2.50
Bavaria	5,128,348	1.99	2.22
France	4,737,250	.95	1.75
Italy	.....	.....	.33
Hungary	.....	.34	.32
Austria	5,313,000	.56	.21
Roumania	482,600	.....	.18
Spain	.....	.....	.17
Sweden	1,677,672	.02	.09
Russia	21,500,000	.01	.032
United States { 1905–6	12,000[2]	.007	.0001[2]
United States { 1906–7	128,659	.0093	.00086

[1] Prepared from the latest available data. [2] Deficit.

There does not seem in the light of these facts to be the least doubt that forestry offers an exceptionally lucrative investment where the capital is at hand to establish it on a scale sufficiently large and when the returns may be deferred for a long term of years. These two considerations—large capital and long time—make it almost imperative that the work be done by government agencies.

Not the least of the advantages of systematic forestry would be the prevention of excessive waste of timber now standing, either by fire or in process of manufacture. For every 1000 feet

of timber now cut, 320 feet are actually used. Since 1870 forest fires have destroyed 50 lives and $50,000,000 worth of merchantable timber per year. The value of young growth destroyed in the same time would now be greater than that of the merchantable timber. These fires could positively be prevented at a cost of one-fifth of the value of the merchantable timber destroyed.

The matter of the advantage or disadvantage of forestry in the modification of natural phenomena is by no means a simple one. Rainfall, drainage, and stream-flow, water storage, and evaporation are always so interrelated and so conditioned by variable circumstances that accurate data is very hard to procure, and even with this given, general deduction or laws applicable to remote regions and periods must be made only with extreme care. Very little accurate data on any of these phenomena as observed in this country is available, and forestry is entirely too young here to furnish much reliable empirical evidence. In Germany and some other European countries, however, a very careful study has been made of phenomena of this sort, and in many Continental countries there is much empirical evidence as to the effect of forests on stream-flow and related phenomena. Theoretically, the casual relation of forests to the modification of natural phenomena may be considered under two general heads,—viz.: influence of forests on general precipitation, and influence of forests on drainage. Either of these would, if considered in detail, occupy more time than I can give to the whole subject to-night.

I. INFLUENCE OF FORESTS ON GENERAL PRECIPITATION.

At the outset it must be admitted that the influence of forests upon precipitation is without definite quantitative solution. There are, however, certain indications both from theory and from direct observation that forests do have a definite modifying influence on the amount of rainfall, and that this influence is in the direction of an increase in the downfall. It is well established that the air strata above forest stations is moister and cooler than over field stations. We would infer, therefore, that the tendency to condensation in a body of air moving over a given stretch of land would be greater over a forest area than over open fields. Is this inference justified? Experience and measurements seem to sustain our reasoning.

TABLE 2.—INFLUENCE OF FOREST AREAS ON RAINFALL IN INDIA.

Name of place.	Distance from the sea.	Mean temperature.				Extreme maxima.[1]	Relative humidity.				Precipitation.			
		April	May	June	July		April	May	June	July	April	May	June	July
Woodless country:	Kms.										Cms.	Cms.	Cms.	Cms.
Lucknow	847	30.1	33.3	33.1	30.4	45.8	30	36	54	74	0.5	1.8	13.3	39.4
Benares	590	30.2	33.2	32.8	29.7	45.0	41	60	81	82	0.5	1.3	12.9	32.4
Patna	445	30.3	31.4	31.4	29.2	44.6	.....	.....	.....	.....	1.0	2.5	16.9	27.8
Barhampur	270	29.6	30.1	29.2	28.7	44.1	52	60	75	79	5.0	10.1	24.2	25.8
Wooded country:														
Goalpara	427	25.2	25.9	26.9	27.7	35.1	66	77	85	84	14.8	33.6	64.3	50.0
Sibsagar	555	23.5	25.3	28.2	28.5	35.6	81	82	83	83	25.9	30.8	39.5	40.6

[1] Mean of two years.

Unfortunately the altitude and slope of the country are not here shown. This incompleteness must necessarily influence the value of the observation, and might affect any deduction to the extent of absolutely reversing our conclusions as to cause and effect.

TABLE 3.—RESULTS OBTAINED IN BOHEMIA.

Time of observation.	Station A (forest glade), 380 metres.	Station B (forest verge), 240 metres.	Station C (field), 380 metres.
	Cm.	Cm.	Cm.
February to April	15.9	16.2	14.9
May to July	18.9	17.1	16.6
August to October	20.7	17.2	15.7
November to January	21.2	18.8	17.7
Year	76.2	69.3	64.9

This table gives the average amount in rainfall for seven years, 1867 and 1868 and from 1873 to 1876 inclusive.

In the years 1879 to 1886, Dr. J. Studika made, in Bohemia, the most exhaustive study of this question which has ever been attempted. The observations were taken from over 700 stations situated at regular intervals throughout the Kingdom. The country was divided into isohytal zones by lines connecting points of equal rainfall. Then, from the observed altitude and precipitation at a sufficient number of stations in each belt, he worked out the average effect of altitude upon precipitation. He found the mean increase to be 69 mm. for each 100 metres of elevation. He then used this result to determine the theoretical rainfall at each of the 700 stations as it should be if determined by the elevation factor alone, arguing that if the observed rainfall differed materially from the theoretical rainfall thus found, there

is an indication that special agencies other than elevation are at work. Of the 48 stations showing the greatest percentage observed in excess of the theoretical rainfall every one was situated in the most densely wooded portions of the kingdom. A number of other observations in different parts of the globe show apparently the same results. It would seem then as far as available facts are concerned the evidence is decidedly in favor of the theory that forests do increase the amount of rainfall.

II. INFLUENCE ON DRAINAGE.

The principal factor in determining the regularity of stream-flow with a given intermittent rainfall is the storage factor of the area forming the basin of the stream in question.

If the storage capacity of the soil and cover of the basin is large and there is a gradual release of the water stored, a very intermittent rainfall may find its way into the water-courses so slowly and gradually that there is little difference between the stream-flow in the wet season and the dry. If, on the other hand, the storage capacity is low, the water must run into the stream almost as it falls, giving rise to alternate periods of flood and low water.

TABLE 4.—AVERAGES OF WATER CAPACITY, EXPRESSED IN PERCENTAGES OF THE WEIGHT OF THE SOIL.

Depth.	Spruce.			Unshaded soil.
	25 years old.	60 years old.	120 years old.	
	Per cent.	Per cent.	Per cent.	Per cent.
0 to 2 inches	30.93	29.48	40.32	22.33
6 to 8 inches	19.19	18.99	19.30	20.62
12 to 14 inches	19.10	16.07	18.28	20.54
19 to 20 inches	18.40	16.26	20.16	20.14
30 to 32 inches	17.91	17.88	21.11	20.54
Average	18.65	17.30	19.71	20.46

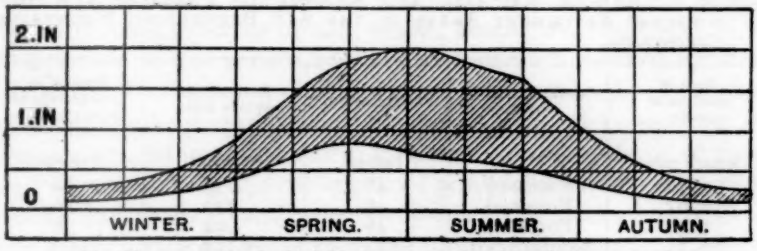
If, therefore, the fact be established that forest soils and covers furnish greater storage capacity for water, and if there are no accompanying circumstances sufficiently powerful to offset this fact, then we have made a good case for forests in their relation to stream-flow.

In this table Ebermayer gives the average results of observation extending over a period of two years. Notice that if the top soil be left out of the consideration the averages as shown at

the bottom of the table are in favor of unshaded soil. If the upper layers be included, however, the figures are as follows: Spruce 25 years old, 24.79 per cent.; 60 years old, 23.39 per cent.; 120 years old, 30.01 per cent.; naked soil, 22.39 per cent. Hence, taken all together, the naked soil contains considerably less water than forest-covered soil. Add to this the storage-capacity of forest litter and of moss, which is exceedingly high, ranging from 45 to 80 per cent., we see that the facts are decidedly in favor of forestry. It is well, too, in this connection to remember that for us in the United States the discussion must not be confined to the difference between forest soil and agricultural soil, but must include differences between forest soil and no soil at all. For, in many instances, removal of trees has resulted in the soil being removed by fire and flood until the rock itself has been bared. In such cases, of course, the storage factor has been reduced to practically zero.

The two main accompanying factors are interception of rainfall by the trees, by which only from 80 per cent. to 86 per cent. of the rainfall reaches forest soils, and evaporation. Time will not permit me to consider these in any detail. Let it suffice to show by table the observed action of the latter factor.

FIG. 1.



Monthly evaporation in the fields (upper curve) and woods (lower curve).

This relates entirely to the evaporation from soil in the forests and the soil under the average agricultural cover. In regard to the amount of moisture evaporated by vegetation itself in the two cases, it may be stated that the results are decided in favor of the forests. The amount of moisture evaporated from the foliage of a deciduous forest rarely or never exceeds three times the amount evaporated from a level water surface. Evergreen forests evaporate less than this, while in an agricultural crop

like maize or alfalfa it may reach eight or nine times the amount given off by a flat water surface.

Careful measurements of rainfall and stream-flow were made in the San Bernardino Mountains, California, during the years 1899–1900.

TABLE 5.—PRECIPITATION AND RUN-OFF DURING DECEMBER, 1899.

Area of catchment basin.	Conditions as to cover.	Precipitation.	Run-off per square mile.	Run-off in percentage of precipitation.
Square miles		Inches	Acre-feet	Per cent.
0.70	Forested	19+	36—	3
1.05	Forested	19+	73+	6
1.47	Forested	19+	70—	6
.53	Nonforested	13—	312+	40

TABLE 6.—RAINFALL AND RUN-OFF DURING JANUARY, FEBRUARY, AND MARCH, 1900.

Area of catchment basin.	Conditions as to cover.	Precipitation.	Run-off per square mile.	Run-off in percentage of precipitation.
Square miles		Inches	Acre-feet	Per cent.
0.70	Forested	24	452+	35
1.05	Forested	24	428+	33
1.47	Forested	24	557+	43
.53	Nonforested	16	828+	95

TABLE 7.—ANNUAL RAINFALL AND RUN-OFF ON FORESTED AND NONFORESTED CATCHMENT AREAS IN THE SAN BERNARDINO MOUNTAINS CALIFORNIA.

Area of catchment basin.	Conditions as to cover.	Precipitation.	Run-off per square mile.	Run-off in percentage of precipitation.
Square miles		Inches	Acre-feet	Per cent.
0.70	Forested	46	731	28
1.05	Forested	46	756	30
1.47	Forested	46	904	36
.53	Nonforested	33	1,192	69

TABLE 8.—RAPIDITY OF DECREASE IN RUN-OFF AFTER THE CLOSE OF THE RAINY SEASON.

Area of catchment basin.	Conditions as to cover.	Precipitation.	Apl. run-off per square mile.	May run-off per square mile.	June run-off per square mile.
Square miles		Inches	Acre-feet	Acre-feet	Acre-feet
0.70	Forested	1.6	153—	66—	25—
1.05	Forested	1.6	146—	70+	30—
1.47	Forested	1.6	166+	74+	30+
.53	Nonforested	1	56+	2—	0

Comment on these figures seems unnecessary.

Switzerland, France, and Italy furnish abundant empirical evidence to corroborate the theoretical results. France, during the years immediately succeeding the Revolution ruthlessly destroyed her forests with the result that she suffered a period of almost unparalleled flood disasters; one thousand of the larger mountain streams became entirely uncontrollable. Eight hundred thousand acres of farm land were ruined or seriously injured. By gradually replacing the forest cover 164 of these are now entirely controlled, and over 600 of the others are showing the beneficial effects of the forests or their water-sheds.

In the deed by which the British Crown conveyed to William Penn and his heirs certain lands in the New World, the tract was called Penn's Sylvania—Penn's Woodland. And it was well-named, for the Pennsylvania of to-day with its great cities, its broad stretches of fertile farm lands, broken by the barren rocky slopes of its mountains and bound together by the vast steel net-work of its railroads, was then an immense forest, broken only by its natural water-courses. Its valleys and bottom lands were covered by dense growths of white and yellow pine interspersed with groves of hickory, poplar, and black walnut. Its mountain slopes bore mighty forests of hemlock, remnants of which still exist. The tops of its ridges in places were covered by hard wood growths of oak, maple, beech, and chestnut. The destruction of this great forest began with the advent of the first settlers. To them it was an enemy to be conquered. With fire and axe the land was cleared for the growing of crops, and, as the sun poured upon the virgin soil there sprang up fields of corn and wheat. Sheep and cattle grazed peacefully where fierce wild-beasts had roamed, and men busily plied the trades of civilized life where a race of wilder men had fought and hunted. Rapidly the clearings pushed toward the mountains, from the East and from the West, until their rocky slopes checked the ruthless slaughter of the trees.

At first very little of the lumber was used; all being burned except that utilized for constructing buildings and fences. Later, it acquired commercial value, and even in the mountains the destruction was more rapid than ever. To-day there is little if any of the State which has not been cut over one or more times.

The land thus cleared, where suitable for agriculture, has

been utilized for that purpose, but where it is steep or rocky it has been abandoned to the mercy of flood and fire. It has burned and eroded until the very bed rock in many places has been laid bare. The sinful waste of the past generation, and the present will be visited heavily upon the next and next and those that follow. Rich stores of coal, iron, petroleum, and gas have been prodigally wasted. But the waste most sinful and far-reaching in its train of evil consequences has been that of the trees and with them the very soil from which they sprang.

Neither the oak nor the hemlock can spring phœnix like from the ashes of its death. The century to grow the tree must wait upon the centuries to replace the soil. And in the meantime what has been the effect of this destruction upon the streams of the State? Scarcely a year goes by without its flood-time and its drought. Last autumn, because of drought, the coal and iron companies were hauling water by the train-load that they might not have to cease operations. Last week flood warnings were sent out along the Ohio and its tributaries that high water might not come upon the people unawares. Pittsburgh has become known as the flood city. The eastern section of the State is but little better. Streams which a few years ago ran with a fairly steady flow now show alternate periods of destructive flood and extremely low water. It would seem that we were in a fair way to repeat the experience of the French people.

The most destructive floods coming as a direct result of forest destruction are the spring floods. The snow accumulates in the mountains during the winter, and in the spring must be melted and carried away either into the soil or directly into the water-courses. In the absence of forests this snow lies exposed to the direct rays of the sun and the first south wind at the advent of spring. The result is that this snow water rushes directly into the water-courses, often before the ice on the stream has been sufficiently softened to pass out quietly. After a hard winter with heavy ice on the streams, and immense quantities of snow on the mountain slopes, these floods become extremely destructive. If the mountain slopes were fairly well covered with trees the snow would not melt away so rapidly, being protected from sun and wind, and, further, the soil being loose and soft would absorb more of the water. Thus the volume of the flood would be greatly reduced, and the water would be reserved for the summer months.

These floods affect directly only the persons and property in the immediate neighborhood of streams. Whatever affects the welfare of any large number of the people of our State, however, must be the concern of all. There are other ways, nevertheless, in which this matter affects very closely those of us who are not endangered personally by high water.

A very important feature is the increased amount of erosion which results from entirely cutting away the timber from the banks of streams and from steep hillsides, which is a direct menace to every citizen of the State. In the first case it results in the banks being eaten into and carried away by the current, in the other case it gives rise to land-slides during periods of excessive rainfall. Take a single glass of Schuylkill or Delaware water during a flood period and set it aside until it settles. Multiply the amount of sediment in the glass by the millions that would represent the number of glassfuls passing in a single hour, and then remember that all this sediment is deposited soon after tide-water is reached. You will then have a faint conception of one of the problems that must be solved in building and maintaining a 35 foot channel from the city to the sea. Now call to mind that at least one-half and possibly two-thirds of this erosion is due to lack of forests and tree protection to the banks of the Delaware and its tributaries and you ought to have a clue to at least a partial solution of the problem. The same argument is applicable to every stream in the State.

We in Pennsylvania and in the United States have sinned grievously in this matter of forests, as we have in many other lines to which our attention has been directed by the late movement toward conservation. Being convinced of our sin, what do we intend to do about it?

Robert Louis Stevenson has written a little fable which I should like to quote in this connection. It is called "The Penitent," and runs something as follows:

"A man met a lad, weeping. 'What do you weep for?' he asked.

"'I am weeping for my sins,' said the lad.

"'You must have little to do,' said the man.

"The next day they met again. Once more the lad was weeping. 'Why do you weep now?' asked the man.

"'I am weeping because I have nothing to eat,' said the lad.

"'I thought it would come to that,' said the man."

Now, being sorry for past wastefulness is not sufficient. Bad as conditions now are, they may become immeasurably worse, and the sooner the work of recovery is begun and the more rapidly it is carried on the more easily shall we meet the results of past indiscretions. We shall need some of the sentiment of Martin Chuzzlewit in this work. The following reads like a bit of inspired prophecy:

MARTIN CHUZZLEWIT ON AMERICA.

"Cheerily! lads, cheerily! Anchor weighed. Ship in full sail. Her sturdy bowsprit pointed true to England. America a cloud upon the sea behind them!

"'Why, Cook, what are you thinking of so steadily?' said Martin.

"'Why, I am thinking, Sir,' returned Mark, 'that if I was a painter, and was called upon to paint the American Eagle, how should I do it?'

"'Paint it as like an eagle as you could, I suppose.'

"'No,' said Mark, 'that wouldn't do for me, sir. I should want to draw it like a Bat, for its shortsightedness; like a Bantam, for its bragging; like a Magpie, for its honesty; like an Ostrich, for its putting its head in the mud, and thinking nobody sees it'——

"'And like a phœnix, for its power of springing from the ashes of its faults and vices, and soaring up anew into the sky!' said Martin. 'Well, Mark, let us hope so.'"

There is in Pennsylvania several millions of acres of land which is not suitable for agriculture. Most of this land has had the original crop of timber cut from it, and very little of it is, in any adequate way, producing another. These conditions, with their inevitable results, which I have pointed out, are becoming increasingly evident, and it is high time something definite is done to meet and remedy them.

Indeed, work to this end is already begun and in some lines is well under way, and needs only the support and co-operation of the citizens of the State to make it still more effective.

There has been some discussion as to the agency for carrying on the work. Some have contended that it should be done solely by the Government, others, that it should be restricted to

the field of private enterprise. It seems very safe to assert that it could be most successfully accomplished by the hearty co-operation of the State and individual land owners.

In every agricultural community there are areas of greater or less extent not well adapted to cultivation. The banks of streams, rocky ridges, swamps, and steep hillsides all lend themselves to the growing of trees, if such were selected as would be adapted naturally to the environment. There is no doubt that this should be the care of the individual land owner, but since his work would result so largely in a common good, he ought to receive every possible encouragement from the State in its performance. The chief reason why it is so hard to get this work done by individuals is to be found in the lack of immediate financial returns. There is no doubt that money spent in this way would ultimately yield a good return on the investment. But it is just as certain that the average American citizen does not relish having to sit idly by, waiting fifty, seventy-five, or a hundred years for his crop to mature. Wheat or corn under the same conditions would suffer equal neglect. Whatever benefits the community would receive, however, would come while the crop was growing. Therefore, the community or the State could well afford to encourage tree cultivation on those small areas surrounded by improved and seated lands.

One of the ways by which such encouragement could be given is by the remission of taxes on land given over to sylviculture. The Forestry Bureau has long advocated such a policy, pointing out that hundreds of thousands of acres of land have been cut over, then the title allowed to lapse because the owners were not willing to pay the taxes for the term of years necessary for reforesting. It is these lands, largely, that are ravaged by fire, year after year, until the smoke from their burning hangs like a pall over the land. There are various other ways in which the individual might be assisted in this work, as, for instance, the necessary experimentation and selection of properly adapted trees. It would seem that the trees themselves might be furnished entirely at public expense or at least at reduced cost to the individual.

In the vast stretches of unseated forest lands which comprise that part of the state traversed by the Alleghany Mountains, the work is so stupendous and the results so far-reaching as to

demand government enterprise. Considered also from the point of view of water supply, it seems advisable that large tracts lying about the head-waters of our principal drainage systems should at least be under government supervision.

There is at present in the region I have mentioned stretching from Pike and Wayne Counties in the northeastern corner of the State to Somerset and Fayette near the southwestern corner some thirteen millions of acres of forest and uncultivated land. Every acre of it should at the present moment be under the administration of some fixed uniform policy of forestry. The State at present owns for Forest Reserve purposes 875,000 acres, at a cost somewhat under $2.25 per acre. It is the policy of the State to largely increase these holdings, the present Commissioner of Forestry believing that the State should ultimately own not less than six million acres. This land is gradually to be acquired as it is advertised and sold for delinquent taxes.

Already difficulty is being experienced in obtaining funds for carrying on the work in the tracts already acquired and more particularly in obtaining men—properly trained, active forest administrators. To meet this latter difficulty a forest academy has been established at Mt. Alto on one of the State Reservations, and each year a group having received a special course of training is added to the men available for this work. But the demand is still much greater than the supply and it promises to become still greater and greater as the State adds more and more to its reserves, to say nothing of that demand which will be created by other States and the reserves of the National Government.

It would require more time than I have at my disposal to take up, except in the most superficial way, the work of the State in connection with these lands and its policy for their future development. Just a few words as to the most prominent features.

First and foremost is the care of the forests now standing and the various stages of growth. The tangle of brush, interwoven with slashings left by the lumbering operations is particularly susceptible to fires in the dry autumn month after the leaves are dried and fallen. Brush, dried tree-tops, and the humus of the very soil itself serve to feed the flames. Once started, unless precautions are taken beforehand, a fire in such a growth must be left to burn until a change of wind or heavy rainfall extinguishes it. To provide against this, fire wardens or rangers

are provided to see that persons guilty of setting such fires purposely or through carelessness are apprehended and properly punished. Also fire roads are cut and kept free from brush and inflammable material; as the flames reach the roads they either die from lack of fuel or are easily extinguished at such places as they may succeed in crossing. Also improvement cuttings are made. In doing this the trees are thinned out. Inferior or dead ones are removed and the lower branches are cut so that the trees may furnish longer logs free from knots when finally ready to be converted into lumber.

Where the land acquired has no suitable growth upon it, trees adapted to the soil and location are set out and cared for until they are able to take care of themselves in the struggle for existence. These trees are raised as seedlings at the nurseries maintained on the Reservations. Abandoned farms in the neighborhood of the Forest Reserves are being purchased by the State for the purpose of planting white pine, it being particularly adapted to this sort of soil. Great care should be exercised in this branch of the work, however, for there is a trend toward reclaiming many of the old farms, and it would be a mistake to take for this purpose land which could be used for agriculture to greater economic advantage when there are millions of acres lying waste which can never be utilized for any purpose save forestry.

I have said nothing concerning the esthetic side of this subject, not because it may in any way be considered as unimportant, but because the critics of forestry may be successfully met upon their own grounds. But everywhere Americans and Pennsylvanians in particular are becoming more and more appreciative of the beautiful things in life. Particularly is this true with respect to the beauties of Nature. The out-of-doors, the green grass, the trees, the hills, the lakes, and running streams are winning their place in care and appreciation of not only the cultured, but the great body of work-a-day people. In this city, at the time when two thousand acres were set aside to form Fairmount Park, the plan was thought to be the extravagant scheme of a dreamer, and met great opposition. To-day the city would cry out in protest at any attempt to reduce it. Indeed there is a strong sentiment in favor of setting aside other tracts to serve the same general purpose. I believe there is no large city in this

country which contributes a larger proportion of its people to the summer camps in the mountains than does the city of Philadelphia. The forest reserves of the State form an excellent nucleus for just such a playground for the people of the whole State as Fairmount Park does to the adults of this city, or as the plots set aside for that purpose do for children of any one locality of the city. Every year the Department of Forestry at Harrisburg is issuing an increasing number of permits for camps on the State Reserves, and this fact presents to the thoughtful, one of the most hopeful aspects of the whole forestry movement. For, even though forestry may be justified from the point of view of mere dollars and cents, it is especially gratifying that it makes a strong appeal to the people of the State on other than mercenary grounds.

GEOLOGY OF THE PHILADELPHIA DISTRICT.

THE Philadelphia folio of the geologic atlas of the United States, published by the United States Geological Survey as No. 162 of the series, is now ready for distribution.

The area described in this folio is the Philadelphia district, which consists of four quadrangles—the Germantown, Norristown, Philadelphia, and Chester. It lies in three States—Pennsylvania, New Jersey, and Delaware—and embraces in whole or in part ten counties, namely, Bucks, Montgomery, Philadelphia, Delaware, and Chester counties, Pennsylvania; Burlington, Camden, Gloucester, and Salem counties, New Jersey; and Newcastle county, Delaware. It covers an area of about 915 square miles and contains a population of more than a million and a half.

The Philadelphia district includes portions of two distinct geologic provinces—the Piedmont Plateau of the Appalachian province and the Coastal Plain—and rocks ranging in age from pre-Cambrian to Recent and in character from granites and gneisses to sandstones, shales, clays, and gravels. The streams of the area reach the ocean through Delaware River, and those in the Coastal Plain are tidal for half or more than half their lengths.

The geography, topography, and geology of this region are described and delineated in great detail in the maps and text of the folio, the authorship of which is divided among a number of geologists. In greater part the folio is the work of Dr. Florence Bascom, professor of geology at Bryn Mawr College, who was assisted by B. L. Miller; but important chapters were also contributed by N. H. Darton, of the U. S. Geological Survey; by H. B. Kümmel, State geologist of New Jersey; and by W. B. Clark, R. D. Salisbury, and G. N. Knapp, also connected with the New Jersey State Survey.

The folio comprises 23 pages of text and 10 map sheets, and is for sale by the Survey.

MECHANICAL & ENGINEERING SECTION

Stated meeting, held Thursday, March 4, 1909.

THE DIRIGIBLE BALLOON WITH GYROSCOPE CONTROL.

THE NAVIGATION OF THE AIR BY MEANS OF THE DIRIGIBLE BALLOON OR AIR-SHIP, PROPELLED BY THE RESULTANT OF THE FORCE OF THE WIND ON ITS SAILS AND THE RESISTANT FORCE OF THE GYROSCOPE.

THE LEVER IN SPACE WITHOUT A FULCRUM ON THE EARTH.

BY

RUSSELL THAYER.

APPROPRIATE to the brief paper which I will read this evening on the subject in question, I will preface it by quoting the following celebrated lines, which may be taken in the nature of a prophecy, written by Lord Tennyson, Poet Laureate of England, a number of years ago:

"For I dipt into the future, far as human eye could see,
Saw the vision of the world, and all the wonder that would be;

Saw the heavens fill with commerce, argosies of magic sails,
Pilots of the purple twilight, dropping down with costly bales;

Heard the heavens fill with shouting, and there rained a ghastly dew
From the nations' airy navies grappling in the central blue;

Far along the world-wide whisper of the south-wind rushing warm,
With the standards of the peoples plunging through the thunderstorm;

Till the war-drum throbbed no longer, and the battle flags were furled
In the Parliament of man, the Federation of the world."

Before proceeding to explain briefly the details of the particular discovery relating to aerial navigation which I have the honor to bring to the attention of the Institute I should refer, I think, in a consecutive manner to the various steps that have marked the progress of the science since the invention of the balloon, something over a hundred years ago.

I think it may be stated that this discovery by man marked

an epoch in this line of scientific investigation, and my own personal studies relating to this subject, which have now occupied in moments of leisure a number of years, force me to the conclusion that the true solution of the problem of aerial navigation is dependent primarily upon the basic discovery above referred to, and it is not at all likely that what is known as the " heavier-than-air " proposition will ever succeed in becoming either commercial or of any great utilitarian value.

Professor Simon Newcomb, LL.D., in an interesting paper published in the *North American Review* of April, 1908, shows conclusively that the proper solution of the problem is rather in the line of the development of the principles of the balloon, and not in reference to the aeroplane.

To briefly quote from the paper of Professor Newcomb, I may state as follows:

" In a word, physical science shows that the larger you build your ship the more economic she is in the ratio of efficiency to cost of running.

" The same principle applies to the dirigible balloon or any other form of ship that is to float in the air. Double its linear dimensions, make its walls twice as thick if you choose, and you will have eight times the cubical space and eight times the buoyant power. But you will require only four times the propelling power to drive her through the air with a given speed, and therefore only four times the horse-power in her engines."

In contradistinction to the above advantages, let us quote Professor Newcomb from the same paper as to the disadvantages of the aeroplane.

" Our principle of the square and cube applies to the aeroplane and to every form of flying machine, pure and simple, but it is reversed in the application. With every increase in the size of the machine, the weight increases as the cube of the linear dimension, always supposing that the model remains the same. Possibly it might not always be necessary to increase the thickness in the same proportion as the length and breadth, but in every case the weight would necessarily increase in a higher ratio than the square of the length or breadth. But the sustaining power being proportional to the surface, or to the spread of wing, whenever we increase the size of the flyer or of the aeroplane the sustaining power diminishes relatively to the size.

"We see this exemplified in the limitations put upon the size and agility of flying animals—the smaller they are the more easily they fly. There is a certain weight which probably is less than the weight of a man, which no bird can ever exceed.

"The principle we have applied does not, of course, set any precise limit to the weight which a flying machine may possibly be made to carry. It only says that the advantage in increasing the size and weight continually diminishes. There is a certain intermediate size where the maximum weight, perhaps that of one or more men, can be carried and this size can never be exceeded with advantage."

Professor Newcomb continues to dwell upon the facts above enunciated with considerable amplification and finally terminates his paper in the following words:

"Bearing in mind that no limit is to be set to the possible discovery of new laws of nature or new combinations of the chemical elements, it must be understood that I disclaim any positive prediction that men will never fly from place to place, at will. The claim I make is, that they will not do this until some epoch-making discovery is made, of which we have now no conception, and that mere invention has nearly reached its limit."

When the principle of the balloon was first discovered, the conclusion at once reached was, that the practicability of aerial navigation was readily within the reach of man, but we have seen that over a hundred years have passed since that event and in a comparatively few paragraphs we can sum up the results of progress made since that time.

First, with regard to the balloon or air-ship, it may be said that it is only within comparatively recent years that any successful attempts have been made to direct its motion of translation through space, irrespective of the direction of the drift of the wind. And it is only within the last twenty years that so-called dirigible balloons have been successfully constructed, all of them working, however, on the same principle or method of propulsion.

The modern structures of this type are all built cylindrical, or cigar shape, and are either forced or drawn through the atmosphere by means of screw-propellers in the same way that an ocean steamer is driven through the water.

The later constructions of this type of air-ship have the screw in front, the shaft driven by the modern high-speed combustion

engine, and the blades of the screw pitched at a proper angle to draw the structure with some considerable speed through the atmosphere.

In the German type of dirigible as recently designed and built by General Count von Zeppelin, the structure is driven by screw propellers projecting transversely from the axis or rigid deck of the air-ship, the propellers, however revolving on axes parallel to the axis of the ship.

In the French construction as used in the French air-ship "*La Patrie*" type, and other French dirigibles, the screw-propellers are arranged in a fore and aft direction, one propeller exerting to pull upon the structure parallel to the axis of the dirigible and the other to thrust parallel to the same axis. The direction of traverse is controlled more or less by a large rudder at the stern of the ship.

The new British dirigibles are substantially on the lines of the French balloons, although the supporting portion is somewhat different in shape, being generally blunter.

Both the French and British systems of construction produce a rigidity of envelope by means of the enclosed gas under greater pressure than the surrounding atmosphere, whereas in the German construction of General Count von Zeppelin the rigidity of the envelope of the ship proper is materially assisted by longitudinal ribs of aluminum, braced, I understand, more or less transversely, and held in place by circular ribs of the same metal attached to the longitudinal pieces at regular intervals. The skin of the envelope is supported on the framework above briefly described. It must be borne in mind that all these structures are drawn or forced through the atmosphere by means of screw-fans, as above referred to. Therefore, they are quite helpless in an ordinary gale of wind and can make progress from one point to another only when the conditions of the atmosphere are satisfactory for so doing.

Notwithstanding the difficulties of the problem and the limits of the utility of the dirigible air-ship, constructed as above described, it is thought that structures of this class will have in all future wars a far-reaching effect, and the attention of military authorities, particularly in Great Britain, Germany, and France, has been especially directed to the use of the dirigible for war purposes.

All of the countries above named are to-day building dirigible air-ships for the use of their armies in the field.

In contradistinction to the method of aerial navigation above briefly referred to is that which has attracted some considerable attention during the past few years, in what is known as the aeroplane. As the principles and performances of structures of this class have been so completely described in the public press during the last year or so I will not dwell upon this branch of the subject to any extent.

While, for the reasons above enumerated in this paper, I do not see that the aeroplane can come into any very general use for commercial or war purposes, yet great credit must be given to the men who have brought this system of aerial navigation to its present condition. There is no doubt also that for certain purposes the present aeroplane may be utilized conveniently and with some degree of success.

We cannot remove from our minds, however, the fact that aerial transportation by means of the aeroplane as it is at present constructed will always be attended by serious risk, as the slightest accident to the structure itself is quite sure to produce results which will be extremely disastrous. This has been shown in the unfortunate and most serious accident which took place at the Government tests of a machine of the class referred to during the past summer at Fort Meyer, Virginia.

Twenty-four years ago,—in the spring of 1885,—I began to give considerable attention to the matter of aerial navigation for war purposes, and at that time designed and submitted to the United States Government a form of dirigible air-ship, which I thought might be of use for Governmental purposes.

The structure which I then designed was substantially, in fact precisely of the same type as the air-ships now being built for the various Governments of the world, except that the method of propulsion which I suggested to be tried was different.

I submitted a picture taken from the publication known as "*Harper's Weekly*," of May 25, 1885, showing a copy of the air-ship which I then designed for the use of the Government.

The matter was considered by the Ordnance Department of the Army, and I understand that an appropriation was asked for the purpose of building one of these structures at the time, but owing to the lack of interest in the matter nothing was done.

The structure which I suggested was propelled through the atmosphere by a powerful jet of compressed air or steam, acting rearwards, as it seemed to me at that time that the difficulties of generating sufficient power to operate a screw-propeller were considerable; in fact you must remember that this was long before the practical development of the modern internal combustion engine, such as we see in use to-day.

I will now endeavor to explain as briefly as possible the recent investigations that I have made in this line, and state why I believe that the results may be of commercial use in the field of aerial navigation.

I have always been impressed with the fact that after the discovery of the balloon the next most important discovery would be to find some way of directing its course through the atmosphere, irrespective of the drift of the wind-current.

As at present used, nothing is more helpless than the ordinary balloon. It simply is blown with the wind; nothing can divert it from that course.

The construction of the modern dirigible balloon, drawn or pushed through the atmosphere by means of screw-fans, only partially solves the problem, as structures of this class, as I have before remarked, are perfectly helpless in a wind of any power.

I will endeavor to show that the discovery which I have made overcomes this difficulty and utilizes the very power which heretofore has been the great obstacle in the control of the flight of a balloon in a given direction not only to propel the balloon at a high speed in various directions through the air but also for the propulsion of the air-ship in quite the same manner as a ship with sails is sailed upon the ocean.

The slightest preliminary thought on this subject will indicate to any one that the difficulties of the problem are insuperable unless we can find in art or nature a means of devising some point or line of support upon which we can take hold, so to speak, in order to utilize the propelling effect of the wind-pressure upon the sails of our ship.

At first the thought will instantly come to our minds that the solution of such a problem is beyond the range of possibility—that the very idea is contrary to the basic laws of mechanics. We have here a body of considerable bulk, suspended in space a mile or so above the earth and driven aimlessly in any direction

in which the wind may be blowing. It is evidently impossible to obtain any hold upon the earth, and it would seem to be impossible to produce within or adjacent to the floating body itself any material substance possessing inertia upon which we could take hold in order to control to a certain extent the movements of this helpless floating structure.

Something must be devised or discovered against which we can oppose the resultant of the pressure of the wind on the sails of the ship; something in fact that will enable us to produce on this structure a condition of two or more forces struggling in unstable equilibrium.

If this condition of affairs can be produced it will be readily admitted by any one conversant with Kepler's laws that the structure acted upon by two forces such as I have above described will take up a motion of translation through space due to the resultant of the two forces.

After a careful study of the entire field of mechanics, I found that one principle and one alone could be utilized to produce the desired result.

The so-called mechanical paradox (which is not a paradox at all), known as the gyroscope, seemed to me to furnish the means sought, and the investigations and experiments that I have made have confirmed my views.

Before describing the use of the gyroscope adapted to the purpose in question it may be interesting to briefly mention the essential facts in regard to this peculiar instrument.

Its definition may be given as follows:

"The gyroscope is the name given by Foucault to an instrument for the exhibition of various properties of rotation, and the composition of rotations first described by Bohwenberger, in 1817.

"The invention is probably French or German, inventor not known; it dates from about the end of the eighteenth century.

"Its action is based on the principle that if a mass is set in rotation about one of its principal axes of inertia of greatest or least momentum, it will continue to revolve about it, and unless extraneous force is applied the direction of the axis will remain unchanged."

This mechanical device, you will thus see, has been in existence for about seventy-five or a hundred years, and its uses

have been limited to certain commercial and practical purposes, which I will speak of later.

I will describe briefly some facts in relation to the gyroscope, quoting from a paper by Professor Arthur Gordon Webster, Professor of Physics at Clark University, Worcester, Mass., published in the *American Review of Reviews,* July, 1908.

"THE PHYSICAL LAW INVOLVED."

"Let us begin with the simplest possible mechanical phenomenon. Everybody knows that a body left to itself can do nothing but move in a straight line with unchanging speed. If we wish to hurry it, we must pull it ahead, and it pulls back; if we wish to retard it, we must pull it backwards, when it will pull ahead; and if we wish to divert it from its straight course, we must pull it sidewise, when it will also pull back or resist.

"This is what we mean by the inertia of a body, namely, its apparent unwillingness to do what we try to make it do.

"Thus the axis of a top, or fly-wheel, can take any direction in space, and all the time the centre of gravity of the top is a fixed point. The top can spin as before quite free from the action of gravity, and if it is carefully enough made the motion of its axis can be perceived in a few minutes. A practical application of this property is made use of in the Whitehead torpedo, which when discharged from a torpedo boat must be steered against the enemy, and carries, instead of a human steersman, a small gyroscope, mounted in rings.

"When the torpedo is discharged, the axis of the fly-wheel points at the enemy. If now a torpedo strikes any obstruction and is turned off its course, the axis of the gyroscope, true to its nature, keeps pointing in the same direction, and thus an outside ring turns relatively to the hull of the torpedo, and moves a little lever, which controls the steering engine, moving the rudder, and thus bringing the torpedo back on its course. It is this gyroscopic gear, invented by Austrian Lieutenant Obry, that has made the torpedo the instrument of precision, capable of doing the damage done by the Japanese to the Russian ships."

"STARTLING PROPERTY OF THE GYROSCOPE."

"We come now to the unfamiliar property of the gyroscope. If, with the top spinning quietly about its axis, we apply a force tending to change the direction of the axis, we find that the axis

resists the pull (or push), and that instead of moving in the direction in which we pull, it moves off in a direction at right angles. This is the *startling property of the gyroscope,* and if we understand this we understand every phenomenon connected with this supposedly mysterious apparatus.

"We can then explain this property by saying that if that force is exerted on a symmetrical top, tending to change the direction of its axis, the axis will not move in the direction of that force, but will tend to move at right angles thereto."

In the same publication and of the same date, Mr. J. F. Springer, referring to some applications of the gyroscope, particularly the wheel and rail problem of Brennan, and the prevention of rolling of ships at sea, by Dr. Otto Schlick of Berlin (which latter will be referred to at more length in this paper), closes his discussions as follows:

"The principles of the gyroscope are truly wonderful in their character. Some of these promise far-reaching and striking results in the world of practical mechanics. Certain of these applications may appear startling in their results. But that in itself is not sufficient reason to regard them as necessarily impossible.

"Let us view the future of the gyroscope in its engineering applications, not with credulity and an unreasoning acceptance of any and all marvels, but with a mind at once open and critical."

A BRIEF RÉSUMÉ OF THE PRESENT USES OF THE GYROSCOPE.

It is interesting to note the various commercial uses to which the gyroscope has been adapted in order to utilize its curious powers.

To the untrained mind it seems to possess mysterious faculties. It will support itself, for instance, suspended in space, at right angles to a cord, resisting continuously the constant force of gravity, while it is spinning at high speed.

Other interesting phenomena may be demonstrated by its means. The laws of rotating bodies, however, are well understood by mathematicians, and, while it is quite true that the mathematics of the gyroscope are complicated and abstruse, nevertheless there is no mystery about the matter, and the forces developed by the gyroscope follow the established laws of rotating bodies which are free to move and rotate at high speed on what I may term elastic axes.

The peculiar property that the axis of a rotating gyroscope possesses of continuously pointing in a fixed given direction, notwithstanding the motion of translation of the earth through space, and its independent rotation on its own axis, has been used by the astronomer for the useful purpose of maintaining the axis of his astronomical telescope constantly trained upon a star that he may be observing, thus being able to keep it continuously in the field of view while otherwise in a few seconds it would pass across the lens.

One of the first uses to which the gyroscope was adapted was to provide an artificial horizon on a moving vessel in order to make observations in marine navigation. For this purpose the gyroscope is caused to revolve on a vertical axis. This was in use for some time, and I believe is still in use in certain navies.

The gyroscope is used very effectually and almost universally in controlling the direction of traverse of the submarine war torpedo, particularly that deadly instrument of destruction known as the Whitehead torpedo now in general use in all navies of the world. In this case it is placed inside the casing and near the stern of the torpedo, and by an ingenious arrangement operates two small rudders which maintain the direction of traverse of the torpedo on its predetermined course. This action is effected by utilizing the same force that I use in aerial navigation, but, of course, in an entirely different manner.

The mono-rail system of Mr. Louis Brennan, uses the forces of the gyroscope to balance the cars on the single rail roadway that is used in this system.

The well-known and costly experiment of Sir Henry Bessemer, made by that distinguished and accomplished engineer about twenty-five years ago, to utilize the principle of the gyroscope to prevent the rolling of ships in a sea-way at sea, may be also referred to. Sir Henry failed in the experiment, for the reason that he overlooked one of the essential laws of the revolution of the gyroscope, and it is said that he expended about a million dollars on this work.

Dr. Otto Schlick, a German engineer of Berlin, first demonstrated the practical utility of the gyroscope in preventing a ship from rolling in a sea-way. I will quote the description of this from the interesting paper of Mr. Henry Smith Williams, published some months ago. (See also the official report read by Sir William H. White before the Society of Naval Architects,

Great Britain, published in *Engineering*, London, April 5, 1907, also on page 794 of *Engineering*, London, June 7, 1907, "Mono-Rail.")

"In the year 1904 Dr. Schlick elaborated his theory before the Society of Naval Architects in London. His paper aroused much interest in technical circles, but most of his hearers believed that it represented a theory that would never be made a tangible reality. Fortunately, however, Dr. Schlick was enabled to make a practical test, by constructing a wheel and installing it on a small ship—a torpedo boat called the *Sea-bar* discarded from the German navy.

"The vessel is 116 feet in length and a little over 56 tons displacement. The device employed consists of a fly-wheel one metre in diameter weighing just over 1100 pounds and operated by a turbine mechanism capable of giving it a maximum velocity of 1600 revolutions per minute. This powerful fly-wheel was installed in the hull of the *Sea-bar* on a vertical axis, whereas the Brennan gyroscope operates on a horizontal axis. So installed, the Schlick gyroscope does not interfere in the least with the steering or with the ordinary progression of the ship. Its sole design is to prevent the ship from rolling.

"The expectations of the inventor were fully realized. On a certain day in July, 1906, with sea so rough that the ship rolled through an arc of thirty degrees, when the balance wheel was not in revolution, the arc of rolling was reduced to one degree when the great top was set spinning and its secondary bearings released. In other words, it practically abolished the rolling motion of the craft, causing its decks to remain substantially level, when the ship as a whole heaved up and down with the waves."

These remarkable results, with more in kind, were recorded in the paper which Sir William White read before the Institution of Naval Architects in April. He himself had witnessed tests of the Schlick gyroscope, and, in common with his colleagues, he accepted the demonstrations as unequivocal.

THE PRINCIPLE OF THE SCHLICK GYROSCOPE.

"Fully to understand the action of Dr. Schlick's invention, one must know that it is not a mere wheel on a single pivot, but a wheel adjusted in such a fashion that it can oscillate longitudinally while revolving on its vertical axis. In other words,

it is precisely as if one of the two gyroscope wheels used in the Brennan car were so placed that its main axis was vertical, its secondary axis, or axis of oscillation, being horizontal and at right angles to the ship's length. Thus while spinning on its vertical axis the body of the top is able to oscillate, pendulum-like, lengthwise of the ship.

"If you apply a brake to prevent the longitudinal motion of the gyroscope, the effect, even though the fly-wheel still revolves at full speed, is precisely as if you pinioned the arms of a strong man, so that he saw the futility of resistance and made no struggle to free himself. Under such circumstances the gyroscope, though it continues to spin as hard as ever, has no effect whatever in preventing the rolling of the ship; it stands there, like the strong man bound, expressing its discontent with an angry groan.

"But if you release the brake so that the entire mechanism is free to oscillate lengthwise of the ship, all is changed. It is as if you cut the cords that bound the strong man's arms. Instantly the mechanism springs into action. It will no longer allow itself to be swung with each roll of the ship; it will resist and prove which is master. Its mighty mass, pivoted on the lateral trunnions, lunges forward and backward with terrific force, as if it would tear loose from its bearings. It causes the ship to pitch a trifle fore and aft as it does so; but meantime its axis stands rigidly erect in the lateral plane, though the waves push against the sides of the ship as before. The decks of the vessel that were tipping from side to side, so that loose objects slid from one rail to the other, are now held rigidly at a level, scarcely permitted to deviate to the extent of a violent tremor.

"The gyroscope has won the contest. To maintain its victory it must continue its backward and forward plunging; but from side to side its axis will not swerve.

"It was the failure to understand that a gyroscope wheel, to work effectively, must be given the opportunity to oscillate in this secondary fashion that led Sir Henry Bessemer to spend an enormous sum in a vain effort to accomplish on a small scale what Dr. Schlick's gyroscope accomplishes for the entire ship."

I have quoted this description of the use of the gyroscope in marine navigation for the reason that it shows the practicability of its adaptation to the purpose for which I have utilized it; and

while it is true that the two systems are entirely different, and that forces are used in my system that are not considered in the least in the former, and that there is a most radical difference in the two things, yet, you will note the comparatively small wheel that controls the torpedo boat, and its very reasonable rate of revolution, all of which indicate the practicability of my discovery.

THE DIRIGIBLE BALLOON WITH GYROSCOPE CONTROL.

This new discovery for the propulsion of dirigible air-ships is based on the development and application of gyroscope forces, in combination with the force developed by the wind-pressure on the sail of the air-ship.

The following well-known law of mechanics may be taken as the basis of this discovery. It is one of the laws which govern the motions of the celestial bodies, the sun, the planets, and the other stars in their revolutions through space: A body suspended in space and free to move in any direction, if acted upon by two or more extraneous forces will take up a motion of translation in the line of its least resistance, due to the resultant of the forces acting upon it.

The following law relating to and governing the movements of rotating bodies, may also be here referred to, viz.: When a body rotating upon a principal axis is subjected to a force tending to produce another rotation not parallel to the former, the resultant effect is such displacement of the axis of the original rotation, with respect to its support, as is most favorable to the parallelism of the two rotations, and such displacement is at right angles to the direction of the disturbing force.

I have discovered that by utilizing the reactive gyroscopic force manifested upon any attempt to change the direction of the axis of a rotary body, in combination with the wind-pressure upon a balloon floating in the atmosphere and carrying said body; that the movement of the balloon may be variably determined and controlled by correlation of the force developed by the gyroscope and the force of the air-current.

In other words my invention provides means whereby wind-pressure tending to diverge a balloon from a predetermined direction of traverse, may be variably opposed by the gyroscopic effect of a rotary body carried by the balloon under the control

of the operator, so that such wind-pressure may be utilized to propel the balloon in directions oblique to the wind-pressure, as in ordinary marine navigation.

The gyroscopic effect that I refer to is due to the fact that a rotary body tends to maintain constant its plane of rotation and consequent direction of its axis of rotation such effect being increased or diminished in correspondence with the speed of rotation of the body.

It is important to note, however, that to render such reactive effect available it is necessary to so mount the rotary body that its axis of rotation is free to oscillate to a limited extent in a direction parallel with the direction of said axis.

The use of the gyroscopic forces that I have described *gives us a line of support against which we may apply and utilize wind force to propel our craft.* Developing the forces of the gyroscope and utilizing them in combination with the wind-pressure in the manner that I do *actually provides a lever in space without a fulcrum on the earth.* The results following from this fact are very interesting.

By the proper use of sail and rudder and gyroscopic forces the dirigible air-ship may be sailed in various directions through the atmosphere, when the wind is blowing at variable speeds, and, as we are navigating on an ocean some five miles in depth, with no rocks or obstructions, you can readily realize the vast possibilities of the dirigible air-ship, particularly for war purposes.

I will now explain the small model that I have here, which shows the resistance of the gyroscope attached to the deck of a dirigible air-ship to the resultant of the wind-pressure on the sail of a ship.

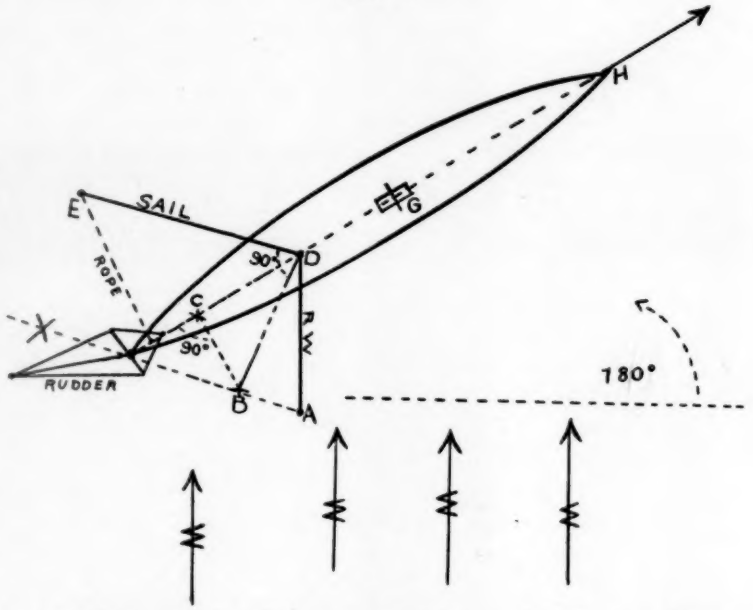
You will note the manner of suspension of the gyroscope hung beneath the deck of the dirigible in such a manner that it is quite free to oscillate like a pendulum, transversely to the axis of the ship; the horizontal axes supporting the entire structure, or, as you will observe, being above the centre of gravity of the rotating mass.

I will show the effect of wind-pressure on the sail of the ship in two ways; first, where the small mast supporting the sail is attached directly to the deck of the dirigible, and, secondly, where said small mast is attached directly to a vertical arm connected with one of the supporting trunnions of the frame of the gyroscope.

The effect in both cases is similar. Two forces are struggling for the mastery of a body floating in space. The forces referred to are the force developed by the high-speed rotation of the gyroscopic wheel and the resultant of the force of the wind on the sail of the ship.

The former force tends to maintain the axis of the dirigible in a parallel direction; whereas the force of the wind-pressure on the sail tends to twist said axis out of its line of direction.

FIG. 1.



W, wind; *RW*, resultant of wind; *DE*, sail. Draw *AX* parallel to *DE*. From point *D* erect at right angles to *DE*, and prolong same until it intersects *AX* at *B*. Draw *BC* at right angles to *HG* and *CD*=force in direction *H* to propel the ship. The structure being held in the direction *HG* by the gyroscope *G*.

The result of the operation of these two forces is, that the body is acted upon by a resultant force tending to give it a motion of translation through the atmosphere on the line of the resultant aforesaid, and also on the line of the least resistance of the entire structure to motion.

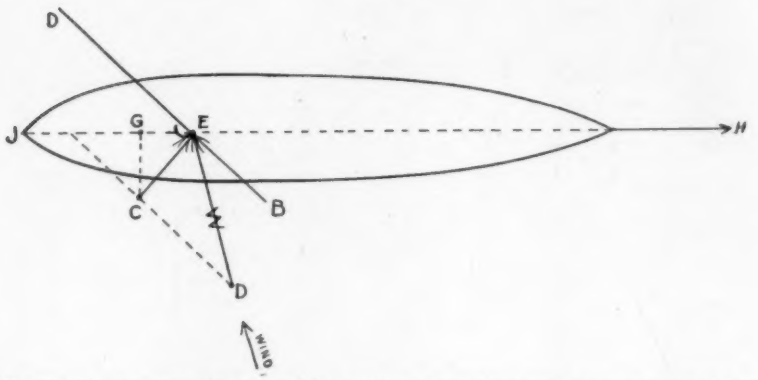
I do not claim absolutely that the dirigible balloon can be driven in any direction through the atmosphere by the forces aforesaid, independent of the direction of the drift of the wind, but

I think it can be readily seen that if we draw a line at right angles to the drift of the wind that the dirigible air-ship can be propelled by the forces in question at any angle measured in the arc of 180 degrees from said line in the direction of the wind drift.

As to the angle that the air-ship can be driven on the other side of said line to the varying degrees of arc against the wind drift, I can only say that I think this can be determined only by practical experiment, as there are so many conditions entering into this problem, such as the shape of the structure, size of its sails, force and power of its gyroscope, skin friction, and other matters which would have to be considered, and can be best determined by practice.

It is evident from what I have said that the gyroscope can also be used to control the direction of traverse of a dirigible balloon

FIG. 2.



DB, sail; *DE*, direction and force of wind; *CE*, resolved component at right angles to sail; *GE*, the effective resolution of this component applied to pushing the ship ahead.

propelled or drawn through the atmosphere by means of screws. In this case the structure would take up a motion of translation parallel to the resultant of the forces applied.

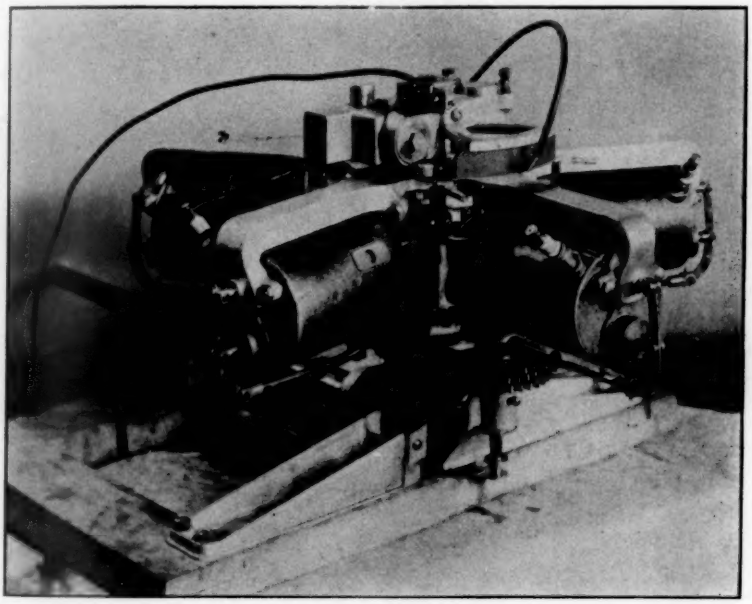
The diagram, Fig. 1, shows the resultant of the force of the wind acting upon the sail of a ship to propel it in the direction *H*, parallel to its axis, and a similar composition and resolution of forces is applicable to the dirigible balloon with gyroscope control. The figures *J H* represent the deck of the ship; *D B* the sail; *D E* the direction and force of the wind on said sail at the point *E*. *C E* will then be the resolved component at large perpendicular

to the sail. *G E* will be the effective resolution of this component applied to pushing the ship in the direction *H*.

In Fig. 2 we show the composition and resolution of forces acting upon the deck of the dirigible to drive same in the direction *H*, as shown. In this drawing *W* represents the wind. *R W* represents resultant of wind-pressure. *D B* represents sail.

Draw *Ax* parallel to *D E*. From point *D* erect perpendicular to *D E* and prolong same until it intersects *Ax* at *B*. Draw *B C*

FIG. 3.



perpendicular to *H G* and *C D* equals force in direction *H* to propel the ship. The structure being held in the direction *H G* by the gyroscope *G*.

CONSTRUCTION OF THE GYROSCOPE.

The gyroscope may be constructed to operate by either a power of steam, electricity, or on the combustion engine principle. I prefer the latter owing to its simplicity, and submit herewith a photograph of a gyroscope consisting of five cast-iron cylinders rotating about the common shaft (Fig. 3). This engine is built

by the Adams Company, Dubuque, Iowa, and is operated in a horizontal position on a vertical axis to propel an automobile. By turning the engine and operating it on a horizontal axis, supported in an oscillatory frame, as shown on the small model herewith submitted, the construction of the gyroscope is at once solved, without the necessity of any expensive experimentation.

The photograph submitted shows engine in a quiescent state and also rotating at a speed of about a thousand revolutions per minute.

THE CONSTRUCTION OF THE ENVELOPE, OR WHAT IS PRACTICALLY THE HULL OF THE SHIP.

Of course in a dirigible it is essential that the envelope should possess a certain degree of rigidity to enable it to be forced through the atmosphere in varying directions and at some considerable speed.

I have heretofore in this paper described the method of construction of the German, French, and English dirigibles, all of which possess the property of rigidity of envelope to a certain degree.

While I do not regard it as at all essential, yet I think it would be quite feasible to construct a dirigible balloon out of plates of rolled aluminum. These plates are 1/100 in. in thickness and weigh .1396 pounds to the square foot. They will stand a tensile strain of 23,000 pounds per square inch.

I think that it will be feasible to construct the body of the dirigible out of plates of this metal lined on the interior with a silk material impervious to gas.

The following calculations show the lifting power of a dirigible balloon cylinder, 200 feet long, 50 feet in diameter, terminated by cones at both ends each 50 feet in length, the said dirigible balloon being made of aluminum plate above described.

CALCULATIONS.

Weight of cu. ft. of air = .0765 lbs.
Weight of cu. ft. of hydrogen = .00527 lbs.
Weight of sq. ft. Al. 1/100 in. thick = .140 lbs.
Weight of government envelope = 5.842 oz. per sq. yard, .04 lbs. per sq. ft.
Area of circle = πR^2

R = radius.

Circum. of circle = $2\pi R$.
Volume of cone = ⅓ area of base × altitude.
Surface of cone = circumference of base × ½ slant height.

CALCULATIONS FOR THE CONSTRUCTION OF A DIRIGIBLE AIR-SHIP.

200 ft. in length;
50 ft. in diameter.
Cylindrical in shape (with pointed ends) bow and stern.
The calculation of the cylinder aforesaid.

This calculation is based upon the following data:
1 cu. ft. of air weighs .0765 lbs.
1 sq. ft. of aluminum metal plate, 30 gauge, 1/100 of an inch thick, weighs .140 lbs.
1 cu. ft. of hydrogen gas weighs .00527 lbs.
$C = 2\pi R. = 2 \times 3.1416 \times 25$ ft. $= 157.08$ sq. ft.
$157. \times 200 = 31400$ sq. ft. = surface of cylinder.
$31400 \times .14 = 4396$ lbs. = weight of cylinder.

Area of base of cylinder, $S = \pi R^2 = 3.1416 \times (25)^2 = 1963.5$ sq. ft.
$1963.5 \times 200 = 392700$ cu. ft. = contents of cylinder.
$392700 \times .0765 = 30041.55$ lbs. = *weight* of air displaced.
$392700 \times .00527 = 2069.52$ lbs. = *weight* of the hydrogen in the cylinder.

Weight of the cylinder = 4396 lbs.
Weight of hydrogen in same = 2069.52 lbs.
Total weight of C. & H. = 6465.52 lbs.

Weight of air displaced by the cylinder which is equal to the buoyant effort = 30041.55 lbs.
Total weight of C. & Hy. = 6465.52 lbs.
Total buoyant effort = 23576.03 = 11 tons +.

THE TWO CONES THAT FORM THE ENDS OF SHIP.

Vol. = ⅓ area of base ⊥ length.
Area of surface = area of base × slant height.
Radius of base.
D = 50 ft. R. = 25 ft. ⊥ = 50 ft. slant height = 70 ft.
Area of base.
Vol. = ⅓ of 1963.5 sq. ft. × 50 ft. = 32725.0 cu. ft. *contents.*

$$\text{Surface} = \frac{1963.50}{25} \times 70 = 5495 \text{ sq. ft.} = \text{surface of cone.}$$

Total 2 cones.....	5006 lbs.
	1883 lbs.
Buoyant effort of both cones....	3123 lbs.
Cones weight	769.3
Gas weight	172.5
	941.8
	.2
Total 2 cones weight.....	1883.6

32725 (contents in cu. ft.) × .0765 (wt. of 1 cu. ft. of air) = 2503.4625 lbs. = weight of air in lbs. in cone displacement, and 32725. (contents in cu. ft.) × .00527 (wt. of 1 cu. ft. of H.) = 172.45 lbs. = wt. of hydrogen in cone.
And
5495 sq. ft. × .14 (wt. of 1 sq. ft. of Al. plate) = 769.3 wt. of cone.
And

769.3 (cone wt.) + 172.5 (gas wt.) = 941.8 lbs.
And
941.8 lbs. × 2 (two cones) = 1883.6 lbs. weight of the two cones, with their gas.
2503 (displacement of 1 cone) × 2 = 5006 lbs. = wt. of the air displaced by the two cones.
769.3 (wt. of 1 cone) + 172.5 (gas wt. in 1 cone) = 941.8 = wt. of cone and H. gas, and 941.8 × 2 = 1883.6 wt. of 2 cones and their H. gas.
Therefore
5006 lbs. (wt. of the air in both cones) —1883 lbs = 3223 lbs. = buoyant effort of both cones.
Total
23576.03 lbs. (buoyant effort of cylinder) + 3123 lbs. (buoyant effort of cones) = 26699 lbs. = 13 tons.

As a corollary to the method of controlling a dirigible balloon by means of gyroscopic forces, as hereinabove described, I desire to submit the following suggestion, in regard to explaining the method of flight of certain birds that are enabled to progress for long distances in the horizontal plane, parallel to the surface of the earth, without moving their wings in the least. Of course the motion of translation of soaring birds and also those which are progressing in planes at more or less of an angle to the surface of the earth is a comparatively simple matter to explain, as it is simply a motion of progression dependent upon the use of the incline plane or the helix; but when a bird such as the albatross will hold its wings perfectly rigid and follow a ship for a number of days consecutively, progressing all the time in the horizontal plane, parallel to the surface of the ocean such progress has never been susceptible of explanation.

Mr. Maxim, I think, and others have attempted to explain this matter by imagining vertical currents of air at right angles to the surface of the earth, which assist a bird in its progression in the horizontal plane.

I think that the hypothesis of vertical currents of air assumed to account for the matter is untenable and impossible of proof and contrary to reason.

I have recently had an opportunity to carefully observe and study the method of sailing of the turkey buzzard, and believe that its motion of translation in the horizontal plane without moving its wings is due precisely to the practical development and action of the forces that I have described in connection with the gyroscopic dirigible balloon.

The bird points its head in the direction that it wishes to go, at an angle to the wind, and consequently maintains its body more

or less rigid in the same direction; its wings acting as sails receive the pressure from the wind, which is resisted by the rigidity of the body of the bird, naturally holding himself in the direction that he wishes to travel—the resultant force impels the bird in the horizontal plane at high speed at an angle to the drift of the wind.

The rigidity of the longitudinal axis of the bird is precisely comparable to the rigidity of the longitudinal axis of the deck of the dirigible balloon, held in that line by the force of the gyroscope. The resultant of the forces of the wind-pressure on the sails and the resistance of the gyroscope to be pushed out of its plane of revolution naturally impel the structure to take up a motion of translation in the horizontal plane and in the line of the least resistance.

INDIA'S MICA INDUSTRY.

THE Consul-General of Calcutta, advises that an American company has acquired a mica mine near Kodarma which is on the East India Railway, 250 miles from Calcutta, and is operating with success. The output in 1907 was curtailed somewhat by financial conditions in the United States, whither the whole production of the mine is exported. The company is really a part of a concern operating in the United States in the manufacture of mica goods of all kinds. The company employs 700 hands at Kodarma and a European assistant superintendent, all under a practical mica man, who is a native of the United States. The company shipped in 1907 200 cases of 100 pounds each and expects to increase the amount. The mica-mining industry in other districts is reported to be steadily increasing. The total exports of mica during 1907 increased by $477,666 over the previous year, or 59.75 per cent.

GROWING EASTERN HARDWOODS IN CALIFORNIA.

The Pacific Coast will soon be the scene of an interesting tree-growing experiment. The United States Forest Service is planning to introduce a number of the more important eastern hardwoods into California, and will this year experiment with chestnut, hickory, basswood, red oak, and yellow poplar or tulip trees. Small patches of these trees will be planted near the forest rangers' cabins in the National Forests, and if these do well larger plantations on a commercial scale will soon be established on wider areas.

There are over 125 different species of trees in California, a number of which produce some of the most valuable varieties of lumber in the country. Although considerably over one-half of the species are hardwood or broad-leaved trees, yet, with the exception of the exotic eucalyptus, there is not a single species of hardwood here ranking in commercial importance with the leading eastern hardwoods. Climatic conditions in many parts of California are undoubtedly favorable for the growth of a number of the valuable hardwoods, and the absence of these trees is due mostly to unfavorable factors of seed distribution.

If the experiments are successful, a valuable asset will have been added to the forest resources of this State, which should prove of special benefit to the local furniture and vehicle industries. Chestnut and red oak are highly esteemed for furniture, while with hickory, basswood, and eucalyptus at its command, California should lead all other States in the vehicle industry.

ELECTRICAL SECTION

Stated meeting, held Thursday, March 11, 1909.

IMPROVEMENT OF POWER-FACTOR AND COMMUTATION CONDITIONS IN SINGLE-PHASE SERIES MOTORS.

BY

A. S. McALLISTER, Ph.D.

Two of the most discouraging characteristics of the series motor which confronted the early designers of this machine were its inherently low power-factor and its destructive sparking. The abandonment of this type of machine some fifteen or more years ago and the development of its rivals for heavy service can be attributed almost exclusively to the existence of these two characteristics. It is well recognized at the present day that a lowering of the frequency of supply simultaneously increases the power-factor and improves the commutation condition, so that the designing of a single-phase series motor for the present-day frequency of twenty-five cycles is a much simpler task than the problem that faced the designer when one hundred and twenty-five cycles was in common use and when sixty cycles was considered a very low frequency.

POWER-FACTOR.

Among the methods that have been devised for increasing the power-factor of single-phase series motors the most popular has proved to be the one by which the wattless component of the voltage is decreased by compensating the armature m.m.f. With perfect compensation the only reactance of the motor circuits would be that due to the alternation of the main field flux through the field coils. By the use of a low value of flux produced by few field circuit turns per pole, the power-factor can be caused to assume a satisfactorily high value when the speed is such as to produce a relatively large counter e.m.f. across the armature; evidently the greater the number of armature turns,

the lower the speed necessary to produce a certain counter e.m.f. at the brushes. It is seen, therefore, that a high operating power-factor dictates the selection of a relatively large number of armature turns as compared with the field circuit turns. The numerical relation existing in the familiar compensated single-phase series motor is fairly well expressed by the statement that at synchronous speed the cotangent of the angle of lag of the current behind the e.m.f. is equal to the ratio of the effective number of armature turns to field circuit turns; moreover, the cotangent varies directly with the speed. The power-factor—the cosine of the angle of which the cotangent is here defined—evidently increases with the speed also, but not in direct proportion.

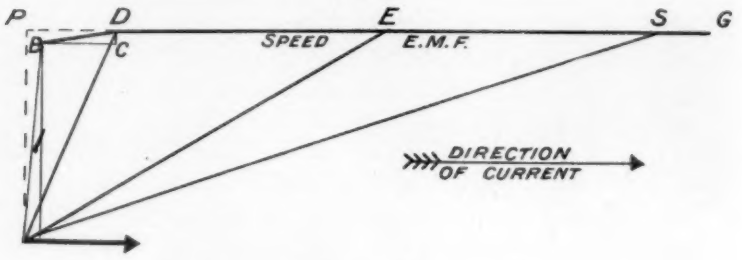
The value of the angle of lag stated above would be absolutely correct if the losses in the machine were negligible, and if the magnetic reluctance of the field and armature cores were constant. Even when the copper losses are taken into consideration, the cotangent of the angle of lag is found to vary directly with the speed, but not to have zero value at standstill. That is to say, at zero speed the cotangent is equal to the total resistance of the motor circuits divided by the total reactance of the motor, the reactance being confined to the field circuit; under speed conditions there is added to the cotangent a value which varies in exact proportion to the speed and at synchronous speed is equal to the effective armature turns divided by the field circuit turns. The iron loss may be treated in part as an effective copper loss and in part as a cyclic change in the reluctance of the core. The cyclic change in the reluctance is in a direction to decrease the angle of lag under speed conditions and thereby to improve the operating power-factor. The latter change, which is small for the whole magnetic circuit and which will be shown subsequently in greatly augmented form, will be neglected in the initial treatment given below.

Fig. 1 shows the vector e.m.f. diagram of the compensated single-phase series motor for unit current; that is, it gives the impedance diagram of the machine. The arrow shows the time-phase position of the current which is assumed to have an effective value of one ampere. *OA* is the resistance volts consumed in the field circuit—the field circuit resistance; *AB* is the reactance volts consumed in the field circuit—the field circuit reactance; *OB*

is the e.m.f. impressed across the field coils—the impedance of the circuit. BC is the resistance volts consumed in the armature and compensating-coil circuits when the rotor is stationary—the resistance of these circuits; CD is the reactance volts consumed in the armature and compensating-coil circuits with stationary rotor—the reactance of these circuits; BD is the e.m.f. impressed across the armature and compensating-coil circuits with stationary rotor—the stationary impedance of the armature and compensating-coil circuits. OD is, therefore, the impedance of the whole machine when the rotor is stationary and COA is the angle of lag of the current behind the e.m.f. at starting.

Under speed conditions there is produced at the brushes an

FIG. 1.



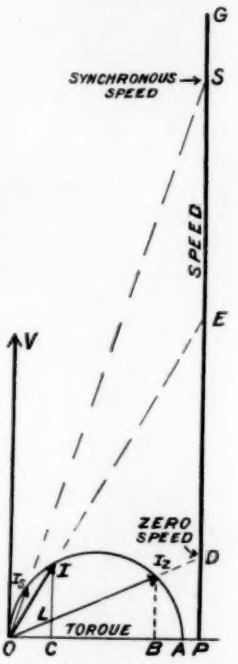
E. m. f. locus (volts at one ampere) of compensated series motor.

e.m.f. in time-phase with the field flux and hence in time-quadrature to the field circuit reactance volts AB of Fig. 1. The speed e.m.f. is shown in direction by the line DG at right angles to BA and DC; it is in time-phase with OA and BC and hence acts as an addition to the resistance e.m.f.; its value is such that at synchronous speed,—represented at the point S,—DS bears to AB the ratio of the effective armature turns to the field-circuit turns. At any speed, such as that represented by the point E, EOA is the angle of lag of the current behind the e.m.f. The cotangent of this angle equal to $(OA + BC + DE) \div (AB + CD)$ varies with the speed and would be proportional directly thereto if the constant value of $OA+BC$ were negligible in comparison with $AB+CD$; moreover, representing the speed with synchronism as unity by S, the cotangent would have the value $S\ (DE \div BA)$ if OA, BC, and CD were negligible in comparison with BA. It should here be stated that the values of

OA and CD may well be considered as negligible, but BC cannot be ignored.

The admittance (current for unit e.m.f.) locus of the machine based on the impedance (e.m.f. for unit current) locus of Fig. 1 without any modifying assumptions is given in Fig. 2. OIz is the current (admittance) at starting; it lags behind the e.m.f. by the angle VOD which is equal to the angle AOD of Fig. 1.

FIG. 2.



Current locus (amperes at one volt) of compensated series motor.

At synchronous speed the current (admittance) has the value OIs and lags behind the e.m.f. by the angle VOS which is equal to the angle AOS of Fig. 1. The locus of the extremity of the current (admittance) vector is evidently the arc of a circle because the motor circuits are electrically equivalent to a constant reactance in series with a resistance, which varies directly with the speed. From the cotangent relations explained above it will be appreciated that the speed can be represented along the line

PDESG—parallel with *OV*,—*D* being zero speed and *S* synchronism. At any point on the line *PFE, DE* is the speed; *OI* is the current; *VOI* is the angle of lag of the current behind the e.m.f.; cos *VOI* is the power-factor; *IC* is the power absorbed by the motor—to a proper watt scale; *CL* is the resistance power loss in the motor circuits; *OC* is the rotor torque—to a proper scale.

In explanation of the loss and torque relations in Fig. 2 it should be stated that in any circle whatsoever the projection of a chord upon a diameter having the same intersecting point at the circumference is proportional to the square of the length of the chord. Thus in Fig. 2, *OC* is proportional to OI^2; since both the field flux and the armature current vary with *OI* the torque, which depends upon the product of the two, is proportional to OI^2, or to *OC*. When the scale is so chosen that *OB* equals the starting torque, then *OC* is equal numerically to the total torque —to overcome both the load and the friction—produced by the current *OI*. Since *CL* remains proportional to *OC* for *all* values of *OI*, it follows the *CL* is proportional to OI^2. Hence, since *BIz* is the copper (I^2R) loss for current OI_z, *CL* is the copper loss for the current *OI*. *CI* being the total power received by the motor, *LI* is the effective power remaining after the copper loss has been subtracted; *LI* can be considered as the sum of the output and the iron and fraction losses of the machine.

It should be noted particularly in this connection that in the diagrams shown in Figs. 1 and 2 full account is taken of the resistance and the reactance of all of the electric circuits without modifications, the only error involved being that attributable to considering the machine to possess constant reluctance in its main magnetic circuits.

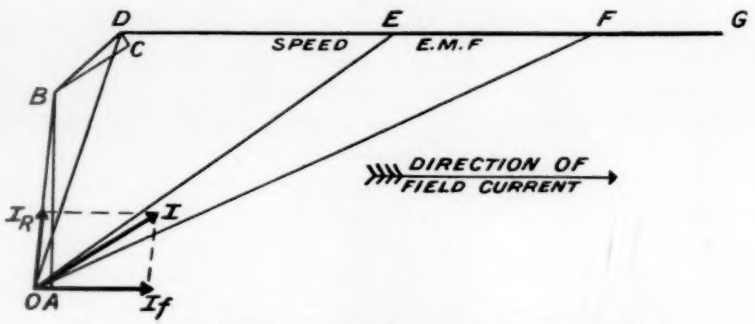
The change in the reluctance of the main magnetic path produces two effects,—on account of "saturation" the reactance is not constant, so that the current locus departs from a true circle; by reason of the "hysteretic angle of lag" between the field flux and the m.m.f., the counter e.m.f. across the armature is not accurately in time-phase opposition to the current, but lags somewhat behind, so that the current tends to lead the e.m.f.; the effect of speed is, therefore, similar to the addition of a slight amount of condensance as well as resistance in series.

POWER-FACTOR IMPROVEMENT.

It is possible to increase the condenser effect to a very appreciable extent by causing the field flux to lag greatly behind the current taken by the motor. This result can conveniently be obtained by placing resistance in parallel with the field coil so that the field m.m.f. lags considerably with respect to the motor current, which latter is the vector sum of the current in the field coil and that in the shunting resistance.

The impedance (e.m.f. for unit field current) diagram of the compensated series motor with shunted field coil is given in Fig. 3, which should be compared with Fig. 1.

FIG. 3.



E. m. f. locus (volts at one ampere of field current) of compensated series motor with shunted field coils.

In Fig. 3, OI_f is one ampere of field current. OA is the field circuit resistance volts; AB is the field circuit reactance volts; OB is the e.m.f. impressed across the field circuit impedance. OI_r is the current in the resistance in parallel with the field circuit. OI—the vestor sum of OI_f and OI_r—is the motor current which passes through the armature; BC—in parallel with OI—is the resistance volts in the stationary armature and compensating-coil circuits; DC—in time-quadrature with OI—is the reactance volts in the stationary armature and compensating-coil circuits, while BD is the e.m.f. impressed across the impedance of the compensating-coil and stationary armature circuits. The total e.m.f. to produce the current OI in the motor at starting is OD.

Under speed conditions there is produced at the brushes an e.m.f. in time-quadrature with the field reactance e.m.f. AB.

The position of this e.m.f. is shown by the line *DEF*—drawn parallel to the line OI_f. The value of the speed e.m.f. for unit field current is the same in all respects as that of the speed e.m.f. in Fig. 1. At synchronous speed it has the value *DF*, the total motor e.m.f. then being *OF* which lags behind the motor current by the angle *IOF* of Fig. 3—instead of leading by the angle *SOA* as in Fig. 1. Hence in Fig. 3 the current is in time advance of the e.m.f. and, therefore, it possesses a leading quadrature wattless (condenser) component.

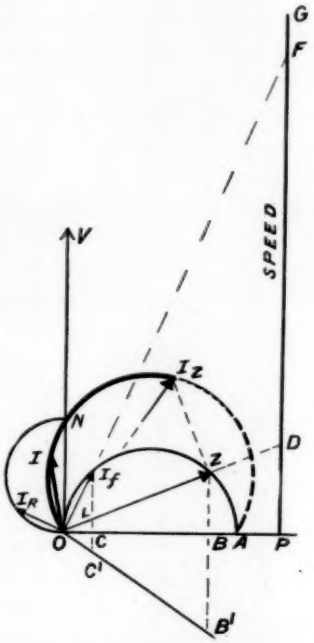
It will be seen from Fig. 3 that the time-phase position of the e.m.f. with respect to the motor current depends not only on the speed but also on the value of the current in the resistance shunting the field coil. The latter current can be varied at will to change the operating power-factor without affecting appreciably the speed-torque characteristics of the machine. When the shunted current passes through an inductance circuit rather than through a non-inductive resistance the torque is increased without affecting appreciably the operating power-factor at each rotative speed. These facts will be discussed more fully below.

It may be well in this connection to describe the current locus at constant e.m.f. of the compensated single-phase series motor with resistance connected in parallel with its field coils. Such a locus is shown in Fig. 4. It differs from the locus of Fig. 2 by the addition of a locus for showing the current passing through the resistance in parallel with the field coil, and of a locus for showing the resultant of the current through the field coil and that through the shunted resistance. Evidently the latter locus shows the current which reaches the armature, which is likewise the current taken by the motor from the supply circuits.

Since the field circuit is assumed to be strictly inductive and the shunted resistance is non-inductive, the currents through these circuits are, under all conditions, in time-quadrature, and they vary in value directly with each other. Since the locus of the field current is a circle, the locus of the shunted current is also a circle; these two circles are at right angles to each other, as shown in Fig. 4. At a certain speed such as represented by *F* in Fig. 4 the field-circuit current would have the value of OI_f while the shunted current would have the value OI_r. The vector (quadrature) sum of these two currents is the current which reaches the armature, as shown in Fig. 4 as *OI*. The locus of

the current OI is the arc of a circle passing through the points O, N, and A. It is evident at once that when the speed has such a value as to cause the resultant current to be within the value represented as ON, the angle of lag becomes negative and the wattless component of the current is leading with respect to the supply electromotive force.

FIG. 4.



Current locus (amperes in each circuit at one volt) of compensated series motor with shunted field coils.

The complete performance of the motor with the resistance in shunt to the field coils can be ascertained directly from Fig. 4. Under starting conditions the field current is OZ and the field circuit loss is represented by ZB; the resultant current is OI_z; the total losses at starting being represented by the line ZB; under any speed conditions such as that represented by the point F; the total losses are shown by the distance LC'. Under the assumed conditions, LI_f is the motor output while $C'I_f$ is the motor input, and the ratio of these two values is the efficiency.

The line *OI* shows the current taken by the motor, while the power-factor is the cosine of the angle *ION*. The torque is represented by the distance *OC*. The speed is evidently shown by the distance *DF*.

It is evident from the discussion given above that the disadvantageous conditions with reference to the lower power-factor of single-phase motors can easily be overcome. It remains now to discuss the methods which may be employed for overcoming the sparking in alternating-current commutator motors.

COMMUTATION.

Even a superficial examination of the circuits of a single-phase motor of the commutator type will show that the coil which is spanned by the brush is the seat of an electromotive force generated by the fluctuations in the value of the main field magnetism which it surrounds. The destructive sparking which was observed in the early type of single-phase commutator motors was due almost wholly to this electromotive force and not to the fluctuations in the value of the main current which passed through the brushes. That is to say, the mere reversal in the value of the alternating-current through the coils of the armature has a negligible effect upon the commutation in comparison with the enormous effect attributable to the short-circuiting by the brush of a coil in which an active electromotive force is generated by transformer action. As a matter of fact, the reversal of an alternating-current presents no difficulties greater than those encountered in reversing a direct-current of equal value, since in any event the frequency of reversal is many times as great as the frequency of alternation in the value of the main current.

The e.m.f. short-circuited by the brush has a value which depends upon the product of the number of turns in the coil under the brush, the value of the field flux, and the value of the main circuit frequency; it can be reduced to a fairly low value by using only one armature turn between adjacent commutator segments, utilizing a small value of field flux, and operating the machine at a low circuit frequency. However, even under the most advantageous conditions the e.m.f. has a value sufficient to produce destructive sparking unless means are employed to minimize its effect.

In motors of the repulsion type, and in certain forms of

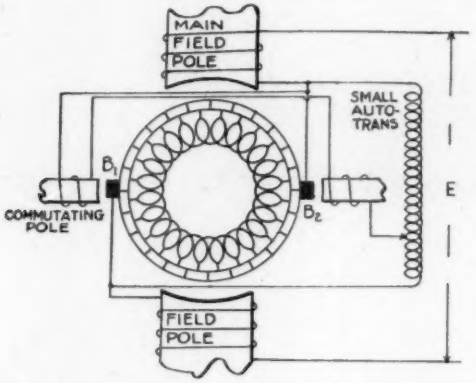
single-phase series motors on which special commutating coils are employed, it is possible to cause to be generated in the coil under the brush by speed action—when the armature is in motion—an electromotive force opposite in direction to the e.m.f. produced in the same coil by the transformer action of the field flux, and thus to reduce automatically the value of that e.m.f. which tends to produce sparking at the brushes. However, this action depends upon the motion of the armature, and it is zero when the armature is stationary. It may safely be stated that the most satisfactory method in use at present for minimizing the sparking in single-phase commutator motors intended for services requiring frequent starting from rest is the use of resistance inserted in the armature leads between the commutator segments and the coils. These resistances are in parallel so far as concerns the main circuit current, but they are in series with reference to the current produced locally in the coil under the brush. When their value is large they involve a considerable loss on account of the main circuit current, but the loss due to the local current is reduced to a negligible value. When the resistance is small the main circuit current loss in the leads is negligible, but the local current loss is enormous. In the practical application of this method, the leads are given such a resistance that the sum of the local current losses and the main current losses is a minimum, which value exists when these two losses are equal. It may be well to note in passing that motors equipped with the resistance scheme for minimizing the sparking have been in extremely severe railway locomotive service for many months without showing any signs whatsoever of trouble at the commutator.

An excellent scheme for neutralizing the e.m.f. in the coils short-circuited by the brush is shown in Fig. 5 which represents a two-pole model of a single-phase series motor equipped with commutating poles. By means of a small autotransformer there is impressed upon the commutating pole coils an e.m.f. in time-phase with the e.m.f. across the armature brushes. Under speed conditions this e.m.f. is in time-phase with the main field flux, and hence is in time-quadrature with the electromotive force produced by the transformer action of the main field flux in the coil, short-circuited by the brush; thus the flux in the commutating pole is in time-quadrature to the main field flux. It will be seen, therefore, that the speed-generated e.m.f. in the coil under the brush is in

time-phase (opposition) with the e.m.f. generated in the same coil by the transformer action of the main field flux. By making the opposing e.m.f. equal to the active e.m.f. in the same coil the resultant e.m.f. reduces to zero and the main cause for sparking is thereby eliminated.

For a certain value of main field flux the transformed e.m.f. in the coil under the brush is independent of the speed, while the amount of flux required in the commutating poles,—to produce by speed action an e.m.f. equal and opposite to this e.m.f.,—should vary inversely with the speed. Thus the electromotive

FIG. 5.



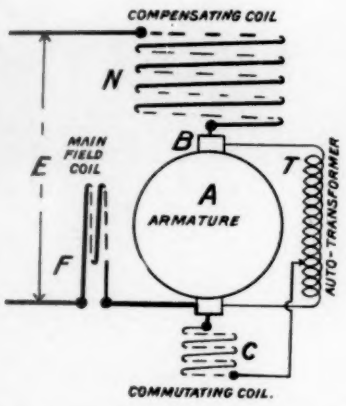
Magnetic circuits of series motor with shunt-connected commutating-pole windings.

force on the commutating-pole coils should be caused to vary directly with the value of the main field flux and inversely with the speed of rotation. This condition can readily be obtained manually by means of the autotransformer.

The magnetic circuits of a single-phase series motor equipped with commutating poles for improving the sparking conditions are well shown in Fig. 5, but the compensating coil for improving the power-factor has been omitted for the sake of clearness. The electrical circuits of this motor are shown more completely in Fig. 6. As intimated above, in order to give to the commutating flux the proper value at each speed it is necessary to vary the voltage impressed upon the commutating coil manually with the change in speed. In order to render the operation of the commutating-pole single-phase series motor more nearly automatic, the scheme

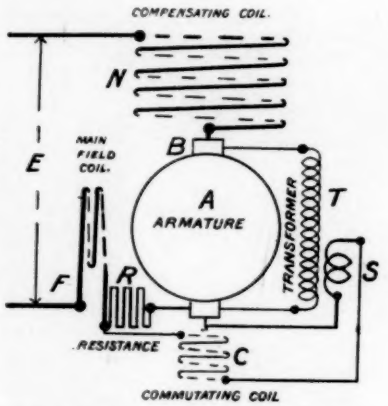
shown in Fig. 7 has been devised by Mr. M. A. Latour. According to this scheme there is impressed upon the commutating coil the resultant of two e.m.f.'s, one of which varies directly with the main armature current, and the other of which varies inversely with the speed. The former of these e.m.f.'s is obtained by placing a resistance in series with the armature circuit, and connecting the inductive commutating field circuit in parallel with this resistance; the second electromotive force is obtained from the secondary of a transformer whose primary is connected between the two brushes on the armature. Thus, on the basis of constant field current, there is impressed across the commutating

FIG. 6.



Electric circuits of compensated series motor with shunt-connected commutating-pole windings.

FIG. 7.



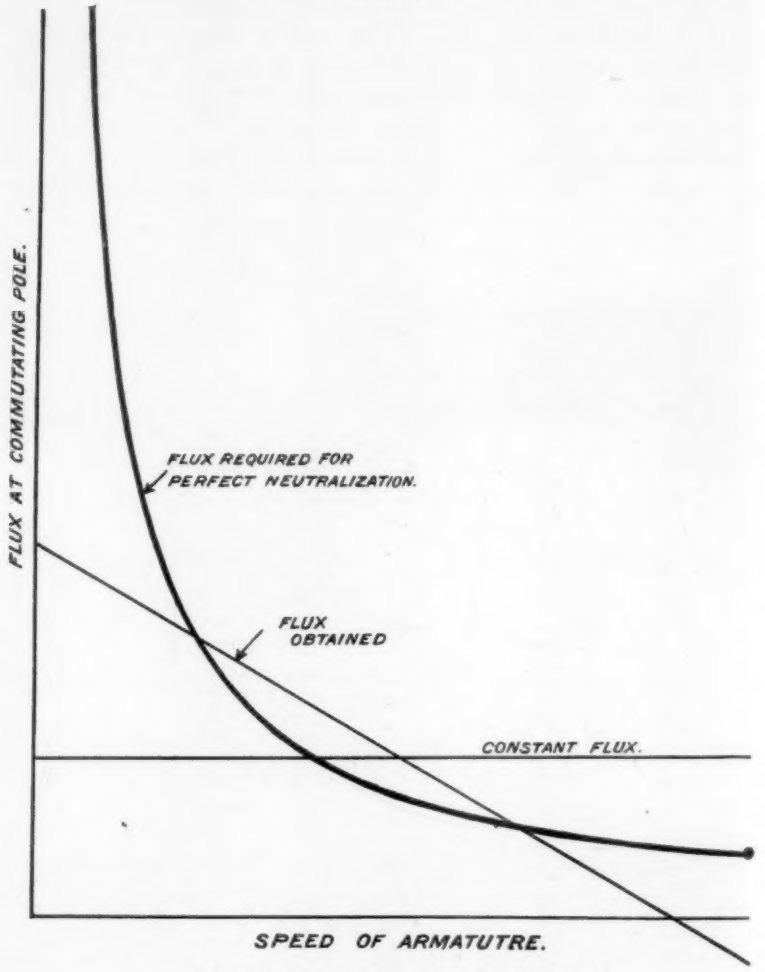
Electric circuits of series motor with automatic split-phase non-sparking arrangement. (Latour).

coil an electromotive force which has a certain definite value at zero speed, but decreases directly with increase of speed.

The relation between the flux required for perfect neutralization and the flux obtained by the method illustrated in Fig. 7 is shown in Fig. 8. The values illustrated in this figure have been based on an assumed constant value of main field current; hence, the relations are correct as far as the relative values are concerned, but the rate of change of each of the various values with increase of speed is not properly shown, because a single-phase series motor is in practice operated at a constant e.m.f. so that the actual current decreases with the increase of speed. It will be noted that for perfect neutralization the flux in the commutating

pole should decrease inversely with increase of speed; it should reach zero value at infinite speed and should reach infinite value at zero speed, thus it is physically impossible to obtain perfect

FIG. 8.



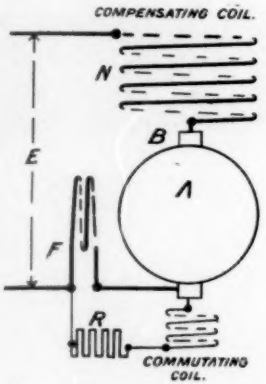
Relation between required and obtained fluxes.

neutralization at zero speed. When the scheme shown in Fig. 7 is used, the flux obtained at the commutating pole decreases at constant rate with increase of speed, and perfect neutralization is

obtained at two values of speed. Moreover, the flux obtained closely approximates the required value throughout a considerable range of speed.

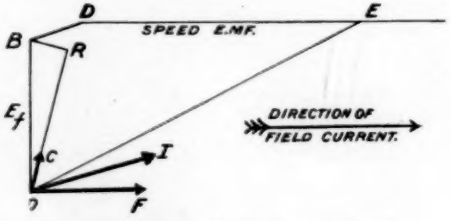
The one serious objection that can be urged against the scheme illustrated in Fig. 7, in addition to that of lack of neutralization at starting, is the considerable loss in the series resistance which is employed for giving the proper phase position and value to the larger of the two electromotive forces impressed upon the commutating coil. It is essential for this resistance to have an appreciable value in order to perform its duties properly. Its use, therefore, involves considerable loss, and lowers the efficiency of the motor.

FIG. 9.



Circuits of high-power factor non-sparking motor.

FIG. 10.



E. m. f. current locus of high-power factor non-sparking motor.

In Fig. 9 there is shown a method for obtaining the proper phase position of the e.m.f. on the commutating coil in order to improve the commutating conditions, and simultaneously to improve the power-factor. It will be noted that the resistance is connected in series with the commutating coil, the resistance and the coil being then joined in parallel with the field winding. The current which passes through this shunt circuit performs two duties; it provides flux for the commutating pole, and has a condenser effect upon the motor circuits. These facts can be explained more readily by the use of Fig. 10.

In Fig. 10, *OF* shows the constant value and phase position of an assumed one ampere of field current. *OB* is the electro-

motive force impressed across the main field coil; this e.m.f. is also impressed across the circuit composed of the commutating coil and the resistance in series. The electromotive force across the commutating coil is represented by the line *BR*, while the e.m.f. across the resistance is shown by *OR;* the current through this circuit is shown by *OC* being in time-phase with *OR*, and in time-quadrature with *BR*. The resultant current through the armature and compensating coil is *OI*, which is the vector sum of *OF* and *OC*. *BD* shows the voltage consumed in the resistance of the armature and compensating-coil circuits. Under speed conditions there is generated at the armature an electromotive force in time-quadrature with *OB;* such an electromotive force is shown at *DE* for a certain chosen value of speed; at this speed the total impressed electromotive force is *OE*, while *EOI* is the angle of lag of the current behind the electromotive force. When the speed reaches a sufficiently high value, the electromotive force lags behind the current, or the current is ahead of the electromotive force, as was explained in connection with Figs. 3 and 4.

It may be well to explain in detail the relative magnitudes of certain quantities represented in Fig. 10. It is evident at once that there are certain practical relations between the main field flux and the flux in the commutating coil which must be taken into consideration in adjusting the electrical circuits. A study of the conditions shows that if perfect commutation is to be obtained at synchronous speed, the flux in the commutating field coil should bear to the flux in the main field coil the ratio of the arc of brush contact to the whole polar arc. This ratio has a certain definite value for each design of motor, and can be changed only by changing the proportions of the machine. If perfect commutation is to be obtained at a different speed, then the ratio varies, having a value which increases directly with the decrease of the chosen speed. Let it be assumed that, at the speed selected, the commutating flux bears to the main field flux a ratio of 1 : 12; then the wattless volt-amperes to produce the main magnetic field bear to the wattless volt-amperes necessary to produce the commutating field the ratio of 12 : 1. The significance of this ratio is that in Fig. 10 the product of *OC* by *BR* must be one-twelfth of the product of *OF* by *OB*. Such a ratio has been selected for Fig. 10, where *OC* is equal to $OF \div 3$, and *BR* is equal to

$OB \div 4$. It is possible to increase the value of OC provided the value of BR is decreased, but the product of these two is a constant and cannot be changed. It is seen, therefore, that it is impracticable to cause the current OC to be in exact time-quadrature with OF on account of the large amount of power which would be dissipated in the shunting resistance R of Fig. 9. Expressed in other words, the arrangement shown in Fig. 9 does not give perfect power-factor conditions, and does not produce perfect neutralization conditions. However, to the extent that the angle of the current is not correct for giving the *maximum power-factor* it is correct for *increasing the torque,* and to the extent that the field flux does not *neutralize* the *transformer* e.m.f. it tends to *compensate for the reactive e.m.f.* in the coil under commutation.

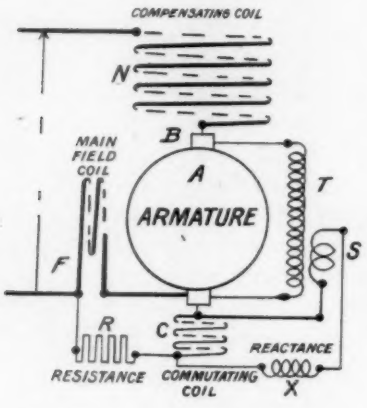
There are two disadvantages in the scheme shown in Fig. 9. In the first place a certain amount of power is dissipated in the resistance in the commutating coil circuit, the amount being practically as great as that involved in the scheme shown in Fig. 7. In addition thereto, the variation of the flux in the commutating pole is not such as to produce perfect neutralization at all speeds; in this respect the scheme of Fig. 9 is much better than that of Fig. 6, but it is not as advantageous as that shown in Fig. 7. On the basis of constant field current, evidently the flux in the commutating pole would have a constant value. As indicated in Fig. 8, under such conditions perfect neutralization would take place at only one speed, and the range of speed throughout which an approximate neutralization would be obtained would be quite limited.

A method which can be employed for rendering the scheme shown in Fig. 9 equally as automatic as that illustrated in Fig. 7 is illustrated in Fig. 11. Upon the commutating pole there is impressed a magnetomotive force which varies directly with the field current, and an opposing magnetomotive force which varies directly with the speed. The commutating pole flux, which is produced by the resultant of these two magnetomotive forces, has a certain definite value at standstill, and decreases at a constant rate with increase of speed.

It is not essential to employ two coils on the commutating pole, since a single coil may be caused to perform the duties of both coils, as shown in Fig. 12. The series reactance indicated in Figs. 11 and 12 is necessary on account of the fact that if it

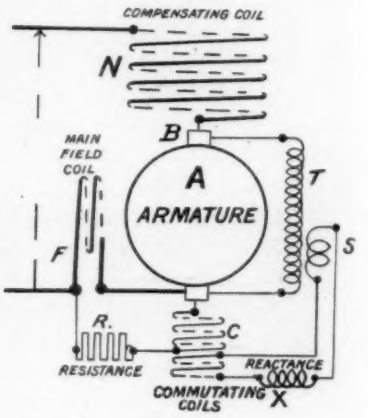
were omitted the flux produced by the coil connected to the secondary of the transformer would have a definite value for each value of the electromotive force produced by the transformer, quite independent of all other conditions; the current in the secondary would have the value necessary to produce this definite amount of flux. When the reactance is inserted in series,

FIG. 11.



Automatic non-sparking, high-power factor motor.

FIG. 12.



Automatic non-sparking high-power factor motor, simplified.

each value of the secondary electromotive force tends to produce a certain definite amount of current in its circuit, so that the *magnetomotive force* impressed upon the commutating coil, rather than the *flux* produced in this coil, depends upon the secondary voltage.

In comparing Figs. 11 and 12 with Fig. 7 it is to be noted that the flux in the commutating coil of Fig. 7 is produced by a single magnetomotive force obtained from an electromotive force which is the resultant of two electromotive forces; while in Figs. 11 and 12 the commutating flux is produced by the resultant of two separate magnetomotive forces, each magnetomotive force being produced by a different voltage.

In so far as concerns commutation conditions, the result obtained with the scheme shown in Figs. 11 and 12 is identical with that indicated in Fig. 7, but the former scheme has the decided advantage of improving the power-factor.

(*Stated meeting, held Thursday, February 18, 1909.*)

GASOLINE ELECTRIC AUTOMOBILES.

BY
JUSTUS B. ENTZ.

Electric gasoline automobiles may be taken to cover all automobiles in which the prime mover or source of power is a gasoline engine, and with which electricity is used as a supplementary power or as a means of control. There are several of such systems. First, there is the combination of a gasoline engine driving an electric generator, which in turn supplies the electric energy to an electric motor or motors connected to the driving wheels.

An electric controller similar to those used on electric automobiles is used to give different speed and torque combinations, and a control of the engine speed allows of a variation of speed for each position of the electric controller. This system calls for the total conversion of the power of the engine into electricity and its reconversion into mechanical power, and is, therefore, heavy and inefficient. This system has also had a storage battery added to it, to help out the engine at times of overload. The battery being charged from the engine and generator at times of light load. This adds further to the weight and lack of efficiency of the system.

A third system seeks to avoid transforming the total engine power into electricity, and so has the engine mechanically connected to the driving wheels with a fixed gear ratio, dispensing with the ordinary mechanical transmission system for changing the gear ratio between engine and driving wheels. There is also connected with the same driving shaft as the engine an electric generator, which is also capable of acting as an electric motor. A storage battery is carried, which, at times of heavy load, discharges into this machine, which is then a motor and assists the engine in turning the driving shaft and propelling the automobile. At times of light load, when the engine is capable of a greater

turning effort than required to propel the automobile, the electric machine becomes an electric generator and recharges the battery. As with a constant field strength the voltage of this electric machine is proportional to its speed, it becomes automatically a generator when the engine speeds up, due to light load, as then its voltage becomes higher than that of the battery and current flows from it into the battery and charges it, while when the engine slows down, due to overload, the voltage of this machine drops below that of the battery, and it becomes a motor receiving current from the battery.

The operator is also given control of the field strength of this electric machine, so that he can determine, through a slight range, at what speed the machine changes from a generator to a motor. In order not to exhaust the battery by an excess of discharge over charge and to keep the proper balance between the two, with the average power requirements of the vehicle constantly varying, means are provided to cut down the engine power when the voltage of the battery, when charging, becomes too high; this is done by means of an electro-magnet connected across the terminals of the battery and controlling the engine throttle. There is also a clutch provided for disconnecting the engine and electric machine from the driving wheels, so that the battery can be charged with the vehicle standing still, and so that the engine may be started up from the battery and motor without starting the car.

The objection to this system is that, in order to avoid carrying a great weight of battery, the electric part of the equipment is capable of adding much turning effort to the driving shaft only at very low speeds, and for a very short length of time, and as the engine and electric motor are both connected to the same driving shaft, the engine has got to come down to a very low speed before it gets any assistance from the battery and motor. The loss in horse-power of the engine from its reduction of speed being much more than added horse-power from the motor and battery, the only thing that is gained is that the engine is not stalled on loads beyond its capacity with the fixed gear ratio provided. If the overload continues for more than a short length of time, the battery is exhausted. The rates of charge and discharge of the battery are very high, and it is therefore short-lived.

It is also very difficult to keep the battery from becoming

exhausted unless it is almost continually overcharged, which means loss of efficiency and a high rate of depreciation.

A system differing from all of these has been in use for the last three years on Columbia Automobiles, built in Hartford, Conn., and is known as the "Direct Electric Transmission System" or "Entz Electric Transmission System."

SOURCE OF POWER.

The system of transmission and control as installed on this car is purely an electric system, the gasoline engine being the sole source of power. The field of an electric generator is bolted directly to the 45 horse-power engine, taking the place of the ordinary fly-wheel. The other end of the field is carried in a large ball bearing.

The armature of this revolving field generator is enclosed within the field, and its shaft is extended through to the driving bevel in the rear axle housing, which contains the bevel gear drive and the differential, these being the only gears in the machine.

NO LOSS OF DRIVING EFFORT.

In line with the revolving field generator and behind it is an electric motor whose armature is mounted upon the same driving shaft, which extends from the armature of the revolving field generator to the driving pinion. The revolving field generator serves the purpose of a clutch, and, by maintenance of current in its field and armature circuits, transmits the full driving effort exerted by the engine directly to the driving pinion, there being no loss of driving effort, as any friction between the armature and field would to that extent transmit a part of the driving effort in the same manner that a friction clutch does. It is necessary, however, to have a small speed difference between the armature and field in order to establish the necessary current through the low resistance of the generator armature and field, which is short-circuited upon itself. This causes a continuous slip, of an amount depending upon the driving effort developed by the engine. This slip, however, amounts to only 5 per cent. of the engine speed when the engine is running at 1000 revolutions per minute and developing its maximum torque. To this extent this revolving field generator acts as a friction clutch capable of trans-

mitting continuously and uniformly, without wear, the full driving effort of the engine. Such a clutch, however, although infinitely superior in its method of control to an ordinary friction clutch, would not provide means for more than reducing the speed of the vehicle in relation to the engine speed, and would not in itself provide means for multiplying the driving effort delivered to the wheels to more than that established by the fixed ratio between engine and wheels. A multiplication of this driving effort, however, is secured by including in the circuit of the revolving field generator, the motor, which is mounted upon the same driving shaft. The current which it is necessary to establish in the field and armature of the generator to transmit the engine torque, can still be established with the motor in circuit, and it will still deliver the driving effort of the engine to the driving shaft without loss; but an increased slip takes place which, instead of appearing as heat, as in the case of a slipping friction clutch, appears as electrical energy, and this electrical energy is utilized in the motor to give the desired added driving effort over and above that of the engine as transmitted by the revolving field generator.

CONTROL.

All changes of speed are made by a small controller handle similar to that of an electric car, which has five speeds ahead and two reverse speeds, and provides means for putting the two armature windings, which the motor has, in different series parallel relation, and also provides means for shunting both the field of the motor and the generator for desired speed combinations. The result is that the driving effort of the engine can be multiplied very greatly, and the maximum effort capable of being developed by this combination can be made available continuously, even with the car at a standstill, as the revolving field generator forms a clutch which may be slipped continuously and uniformly, and which will deliver the result of its slippage as useful power instead of heat.

The control involves absolutely no change in the mechanical relation between the engine and the rear axle, and in going from point to point does not disconnect the driving effort of the engine from the driving pinion. Only the power represented by the difference of speed or slip between the field and armature is transformed.

CAPACITY OF GENERATOR AND MOTOR.

The capacity of the electrical clutch generator and motor in this system is about four times greater than it would be with a generator and motor considered simply as such; that is, they will transmit and control the power of the engine with one-quarter of the weight and far greater efficiency than would be the case if all the power of the engine were used to drive a generator, which in turn delivered it to the motor to be transformed into mechanical energy.

The result is that actually less than 10 per cent. more weight is added to the vehicle than would be called for if it were equipped with sliding gear transmission, clutch, and fly-wheel. The efficiency of transmission is very high, being 95 per cent. on the high speed, and from 85 per cent. to 92 per cent. on the lower speeds.

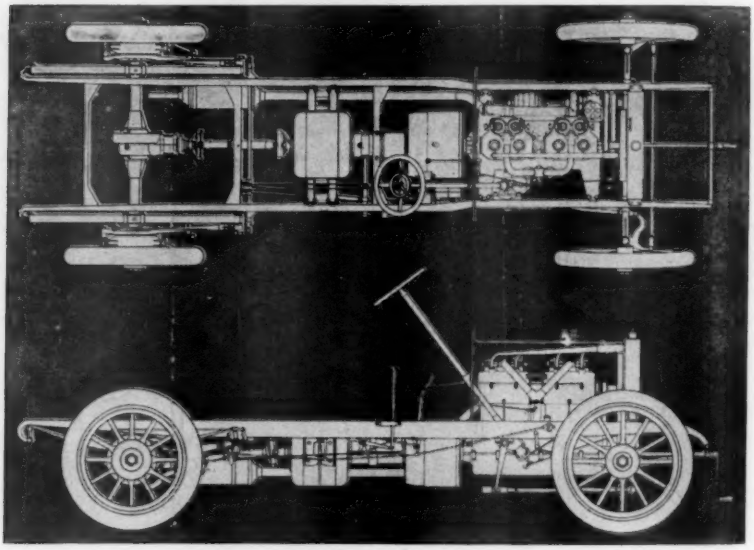
REVERSING.

Reversing is accomplished without the use of gears by clutching fast the armature in the revolving field generator, and at the same time disconnecting it from the driving shaft leading to the rear axle. In this way the revolving field generator loses its clutch action and becomes simply a generator, stationary armature, and revolving field. The motor, whose armature is still connected with the driving shaft, receives current from this generator and drives the car either forward or backward, according to the relation of its field and armature connection. Under these conditions the system is simply a motor dynamo combination, but as reversing is only necessary for short distances at low speeds, this is amply sufficient, and is much simpler mechanically than the use of a reversing gear, although the latter may be used when it is desired, as in railway service, to have equal capacity and efficiency for running in either direction.

Figure 1 shows a plan of the running gear of this automobile. The machine shown next to the engine is the generator clutch, and the other is the motor. Figure 2 shows the generator with its collector rings and the clutch sliding on the squared end of the generator armature shaft, which is used for reversing, as explained. In order to show the gain in efficiency and the less weight of the electrical apparatus, as used in this system, as compared with one in which all the power of the engine is transformed into electricity by means of the engine driving an electrical

generator and retransformed into mechanical power by means of an electric motor, I have in Fig. 3 shown the conditions in the latter case. The crank shaft is shown connected to the field of the electric generator, whose armature is stationary, being held from turning by the rod attached to its shaft. This is not the usual practice, as generally the armature is revolved and the field held stationary, but it makes no difference in the capacity or efficiency of the generator, and it is so shown, for the purpose of comparison with the other figures.

FIG. 1.

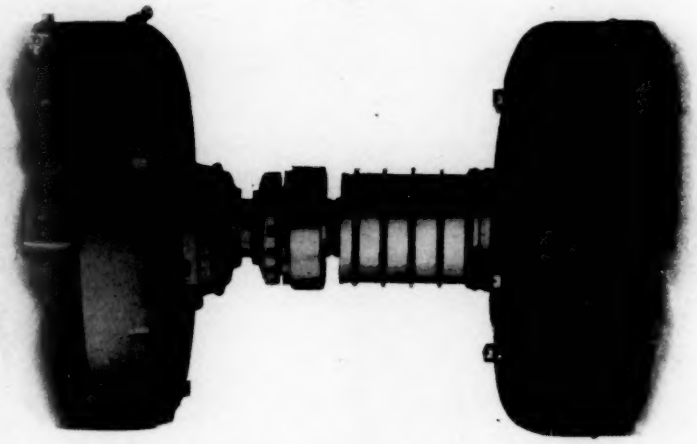


I have assumed that the engine is revolving the generator field around its armature at 500 revolutions per minute, and that it is developing a turning effort of 100 pounds. I have also assumed that the generator and motor each have an efficiency of 80 per cent., which is about the efficiency of such units of a size to be used in automobile work. The combined efficiency of the two, therefore, is 64 per cent. I have assumed that the generator and motor are so wound that the motor will run at 500 revolutions per minute, the same as the engine. In this case the entire loss in the efficiency must be in the torque or turning effort of the

motor, which would be 64 per cent. of the engine torque or 64 pounds. The engine develops the torque of 100 pounds and has its sole resistance to motion in the current generated in the generator armature and whatever friction there may be due to pressure of the brushes on the armature commutator. The armature, therefore, must be held from revolving, by a resistance to motion, equal to 100 pounds torque in order to resist the whole turning effort of the engine.

In Fig. 4, which illustrates the new system, I have shown precisely the same electrical apparatus as used in Fig. 3. In this case the generator armature, instead of being anchored stationary,

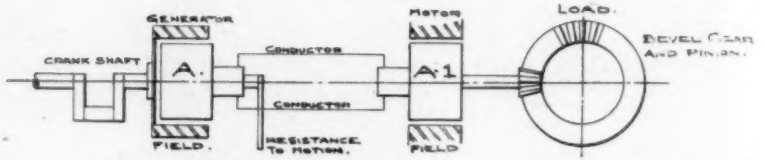
FIG. 2.



has its armature shaft connected with the armature shaft of the motor. If the motor is still assumed to run at 500 revolutions per minute, and to develop the same turning effort as before, it must receive the same amount of electricity from the generator. This is accomplished by revolving the generator field at 500 revolutions per minute faster than its armature, and as the latter is turning at 500 revolutions per minute it will be necessary to turn the generator field and engine at 1000 revolutions per minute. This calls for double the output from the engine, but the full turning effort of the engine of 100 pounds torque has been transmitted directly to the driving shaft and added to that of the motor, so that we have on the driving shaft a torque of 164

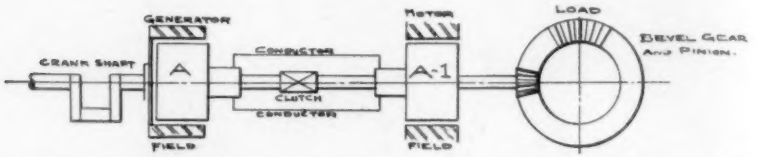
pounds at 500 revolutions per minute, or an output two and a half times as great as in Fig. 3, with the same capacity of electrical apparatus, and an efficiency of 82 per cent. instead of 64 per cent. This, however, is not the full gain, as this figure represents one of the lower speed positions, which is used only a short part of

FIG. 3.



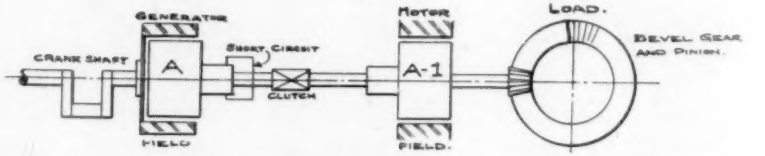
Generator and motor, each 80% efficiency. Engine 500 rev., 100 torque; motor 500 rev., 64 torque; efficiency 64%.

FIG. 4.



Reduced speed. Engine 1000 rev., 100 torque; motor 500 rev., 164 torque; Efficiency 82%. Exactly same electric output from generator to motor. Same speed differences, but 2½ times output, same weight, for same machines as in FIG. 3.

FIG. 5.



The clutch generator short-circuited on itself. High speed direct drive. Engine 1000 rev., 100 torque; shaft 950 rev., 100 torque; efficiency 95%. No current through motor. No external electric work. Output three times that of FIG. 1.

the total running time. The highest speed position, and the one that is mostly used, is shown in Fig. 5, in which the generator armature is circuited upon itself. In this case the generator field is turning only slightly faster than the armature, which it drags around after it. This difference of speed or slip, in the case of a generator having the efficiency assumed in the other cases, would be 50 revolutions per minute when transmitting the full torque

of the engine, and, as there is no loss of torque, we would have, with the engine running at 1000 revolutions, the speed of 950 revolutions and 100 pounds torque.

This output is three times as great as in Fig. 3, and with the motor doing no work at all, and the efficiency is 95 per cent. instead of 64 per cent., as in Fig. 3.

BRAKES.

In connection with the control, an electric brake is provided, and there is also a connection between one of the foot brakes and a small short-circuiting switch, by means of which the field of the generator is short-circuited when the brake is applied. This immediately stops generation and answers exactly the same purpose as throwing out the friction clutch on an ordinary car upon the application of the brake, so that, to bring the car to a standstill, it is only necessary to put on the brake.

COASTING.

In order to establish any current in the circuit of the generator it is necessary that there should be a slight slip between the field and the armature; in other words, the engine should run slightly faster than the driving shaft to which the armature is connected. With the engine slowed down by a partial closing of the throttle, there is no clutching action and the car may coast ahead of the engine without any retarding effort, and in this way the combination acts exactly similar to a coaster brake on a bicycle. This adds very greatly to the ease of control and allows driving and coasting in perfect silence, entirely free of any connection with the intermittent driving or braking effort of the engine. It also permits regaining speed and headway much more rapidly than would be possible with the ordinary gasoline car, because as the engine is speeded up again by opening the throttle, it attains a speed some little higher than the speed of the car before it starts generating and picks up its load. Although this interval of time is but a fraction of a second, the speed gained in that time and the elastic method of clutching to the load, coupled with the great inertia of the fly-wheel, (which is of about three times the ordinary weight,) permit a very high rate of acceleration under load.

EVEN PROPULSION.

There is no direct mechanical connection between the engine and the driving shaft, and as the clutching medium is perfectly elastic, there is absolutely none of the intermittent driving effort of the engine transmitted to the driving shaft and wheels; also that it is impossible for the engine to have a retarding effort upon the driving shaft. There can be absolutely no "bucking" from the loss of a cylinder. The most expert factory testers find it difficult to detect the cutting out of a cylinder except through the diminution of available power. The propelling effort is apparently just as even and constant with three out of four cylinders running as with all four.

RUNNING BACKWARD.

On all points of the controller, both zero, forward and reverse, the circuit of the electric motor is closed upon itself. The result of this is that, being a series motor, it has no tendency to generate when armature and field are coupled in a relation for the desired direction of motion of the car, but if for any reason the driving effort from the engine should be lost, as by stalling on a grade, the instant the car commences to run backward the motor will generate and act as a brake, not permitting of a speed of more than one mile an hour even upon a very steep incline. This, in effect, is an automatic sprag, or ratchet, which must come into play the minute the car gains any backward speed on any position of the controller.

IGNITION.

Ignition is by jump spark, with current from a storage battery, in combination with a small amount of current diverted from the generator, by means of which not only is the storage battery always maintained charged, but the heat of the spark is also increased automatically with the load on the engine.

SPEED.

The speed of the car is from one-half a mile to fifty-five miles an hour, and its ease of control and ability to adapt itself to varying conditions of road and traffic make it a considerably faster road car than even its maximum speed would indicate. Its hill-climbing powers are remarkable owing to the elimination of practically all friction. The car has taken on the highest speed notch every hill on the 125 miles of road between Hartford and New York City.

COMMITTEE ON SCIENCE AND THE ARTS

THE GAYLEY DRY AIR BLAST.

[Report of the Franklin Institute, through its Committee on Science and the Arts, investigating the Dry Air Blast for Furnaces invented by James Gayley of New York. Subcommittee: G. H. Clamer, Chairman; John M. Hartman, James Christie, Anson W. Allen, Alex. E. Outerbridge, Jr., Robert Job. No. 2412.]

THE aim of the modern blast furnace is to maintain a uniform and highest-practicable temperature at the point of fusion in the crucible of the furnace. To obtain uniformity of product the raw material introduced must be reasonably constant, a condition that can be practically maintained—in all respects excepting the moisture in the atmosphere, which is constantly changing, according to season and locality—also as influenced by wind, temperature, and other weather conditions. As the quantity of aqueous vapor in the atmosphere has been found to vary from .04 to .16 per cent. of weight, and as its presence exercises an important influence on the combustion of the fuel in the furnace, it can be seen that this element, which is recognized as one of the chief disturbing influences in the atmosphere, might also exercise an important part in blast furnace economies. Any moisture introduced by the air-blast absorbs some of the heat directly, but indirectly much more is taken when this moisture meets the incandescent fuel, when it is broken up into its constituent gases, at the expense of heat, which is thus withdrawn from the zone of fusion, and exercises a retarding influence, even if the heat of final combustion is utilized elsewhere.

The beneficial effect of dry air appears to have been observed by the iron smelters at an early period, when it was found that their product was better in the winter than in the summer season. This at first was attributed to atmospheric temperature alone, and some experiments were made by cooling the air. It was soon found, however, that the inferior product of the furnace

was due to moisture, and it is recorded that artificial drying of the air was made the subject of direct and successful experiment at some of the furnaces of the Clyde region in Scotland, before the introduction of the hot blast (*Practical Mechanics & Engineers' Magazine,* Glasgow, 1842). Neilson apparently realized this, for he proposed to dry the air by passing it in contact with lime, on its passage to the furnace (Smiles's "Life of Neilson"). These crude and imperfect attempts were abandoned after the general introduction of the hot blast, which to some extent counteracted the disturbing influence of moisture, and during the latter half of the past century the subject of eliminating moisture appears to have been practically dropped.

Mr. James Gayley, a few years ago, studied this question carefully, and was fortunate enough to be placed in such a position that he was enabled to carry on the necessarily expensive experiment of producing dry air blast by refrigeration.

The dry air blast, which is the subject of this report, is produced in this manner, process and improvements thereon being protected by the following United States patents:

Number	527,844	dated	October 23, 1894.
"	594,243	"	November 23, 1897.
"	652,178	"	June 19, 1900.
"	652,179	"	June 19, 1900.
"	715,366	"	December 9, 1902.
"	746,814	"	December 15, 1903.
"	756,110	"	March 28, 1904.
"	771,058	"	September 27, 1904.
"	779,037	"	January 3, 1905.

The standard refrigerating machinery which is on the market has been used, but of course modified to some extent to meet the requirements of this particular service. It is calculated that 11,900 lbs. of air are consumed per ton of iron reduced. This air may vary in its moisture content from 20 to 100 per cent., such variations being very often quite decided, even within the short space of a few hours, the moisture contained during the hot summer months of course being on an average very much higher than during the winter months. The variation, however, from day to day during the winter months is greater than during the summer months. In the Pittsburg district, where Mr. Gayley's first experiments were tried, an examination of the U.

S. Weather Bureau Reports shows an average monthly temperature of 31 7-10 (coldest month, *i. e.*, February) and 76 2-10 (warmest month, *i. e.*, July). The average moisture content expressed in grains of water per cubic foot of air is for February 2.70 and June 7.30. From a calculation of the moisture content of the atmosphere it has been figured that the quantity of water entering per hour into a furnace using 40,000 cubic feet of air per minute will vary from 73 2-10 gallons in February to 237 6-10 gallons in June. These records, however, are taken on top of a high building, as all such records of the U. S. Weather Bureau are, and therefore do not really represent the maximum moisture content which would exist in the air at the steel works, where the same would be considerably higher. In the past, great attention has been paid to bringing the furnace operations on as uniform a basis as possible. The charges of coke, fluxing material, ore, and quality of same, are all based on careful chemical analyses and scientific calculations. Important improvements have been made in all the various blast furnace accessories, and a great deal of attention has been paid to size and shape of the furnace and in the construction of more efficient blowing engines, etc., but that element, *i. e.*, the air blast, which varies more widely than any of the other factors entering into the operation of the blast furnace, until the matter was taken in hand by Mr. Gayley, had received insufficient consideration. It had of course been figured how many calories of heat were necessary to take care of the amount of moisture which was introduced into the furnace, but little thought was given toward the subject of drying the air. The application of Gayley's dry air blast has been in successful operation for some time past, and it has now entirely passed the experimental stage, and has proved itself to be one of the most important advances which have been made in the manufacture of pig iron. The advantages claimed for the dry air blast, all of which have been sustained, are as follows:

First.—Dry blast, when put on a furnace in operation, will cause approximate reductions of 15 per cent. in the coke consumption, and an increase of 10 per cent. in the iron production.

Second.—Dry blast, when supplied to a furnace at the beginning of a blast, will keep the same in more regular uniform operation throughout its whole life, and will hold the zone of fusion

more steadily near the tuyeres, thus causing more efficient reduction and melting and greater economy in fuel. The fuel consumption for a whole blast should remain at about the same figure with the use of dry blast.

Third.—The life of the lining will, under ordinary conditions of operation, be increased up to 30 per cent. by the use of dry blast.

Fourth.—The use of dry blast, coupled with clean gas, will enable the use of higher heats of the blast, thus causing an extra coke economy. As the dry blast prevents fluctuations up or down in the melting zone, it will be possible to use higher heats than at present, or up to 1500 degrees, and probably higher with our Mesaba ore mixtures, and yet prevent sticking in the furnace through high heats of blast. The reduction in revolutions will in itself cause a higher temperature of blast from the stoves as the air passes more slowly through them.

Fifth.—The use of dry blast effects a saving in the limestone consumption of from 5 per cent. to 10 per cent., according to the ash contents in the coke used. This is due to the lowering of the amount of coke used and the fact that a more silicious slag can be carried, as the heat, being concentrated near the tuyeres, is more intense, and consequently will enable the more highly-heated slag to carry off sulphur more readily.

Sixth.—The use of dry blast causes a very marked regularity in the silicon and sulphur contents of the pig iron, which is especially important on basic iron for the open hearth.

Seventh.—The increased production caused by dry blast affects the cost above material and the profits to the corporation proportionately.

Eighth.—The use of dry blast reduces the flue dust made by about 50 per cent., owing to the concentration of the heat at the tuyeres zone, which causes more regular operation, thus preventing slipping. The temperature of the top gases is also lowered by the concentration of the heat at the tuyeres zone, and hence leaves the furnace with less velocity, thus carrying along less fine material.

Ninth.—The use of dry blast requires 15 per cent. less air blown by blowing engines, thus making a considerable saving in the wear and tear, and hence in the life of the engines, as well as causing a material saving in horse-power.

	H. P.
At Isabella furnace the engines required on normal air	2,700
The engines required on dry air	2,100
Making a saving through use of dry blast of	600
The dry blast plant required	331
Making a net saving through use of dry blast	269

This saving, based on the cost of gas firing at Isabella with $1.45 coal, has been calculated to amount to nine cents per ton of pig iron.

Tenth.—The use of dry air, causing more perfect work in the chemical reactions in the furnace, may have a tendency to reduce the amount of CO in the gas, so that the latter may not be as efficient from the standpoint of heat and power purposes. On the other hand, it is much cleaner, more uniform, and will require less work in handling of dust than with normal air. Its uniformity will probably counterbalance any lower heat value.

The average analysis of dry air gas at Isabella to date shows:

CO	23 per cent.
CO_2	14.1 per cent.

The average analysis of natural air gas at Isabella for the same period:

CO	24.7 per cent.
CO_2	12.6 per cent.

Eleventh.—Through the uniformity in operations produced by dry air an increase of fifty to seventy per cent. in the standard grade of iron is obtained.

Twelfth.—With dry blast the silicon can be materially reduced without increasing the sulphur. Iron running as low as .10 silicon has frequently been made with a sulphur content of .04 per cent.

It is not deemed necessary to go into minute details of the application of Mr. Gayley's dry air blast in this report, but there is attached hereto a report on its operation on the Isabella furnace in 1907 at E. & G. Brooke Iron Co., Birdsboro, Pa., together with its effect on the silicon and sulphur content of the iron produced, also a report on its application at the Cardiff works

of Wales, and a still later report, which appeared in the *Iron Age* under date of January 2, 1908, of its operation at the Warwick Iron and Steel Company's furnace at Pottstown, Pa.

It should be noted that the greatest economy experienced in the application of the dry air blast has been by reason of the uniformity of the operation of the furnace rather than from the direct saving which is occasioned by the elimination of the moisture content—this for the reason more particularly that the furnace charges can be calculated nearer to the theoretical requirements, it not being necessary to provide a large factor of safety, as is essential where the dry air blast is not used.

Because of the originality of this invention and the importance of the results accomplished, the Committee recommends the Institute's highest award, *i. e.*, the Elliott Cresson Medal to James Gayley of New York.

RESULTS OF DRY AIR BLAST AT E. & G. BROOKE IRON CO., BIRDSBORO.

	Average daily product tons.	Average coke consumption pounds.	Average yield of ore—%.	Average ore burden carried to coke.
NATURAL AIR:				
Year 1906	146	2455	53.0	1.72
January 1906	131	2443	56.64	1.62
DRY-AIR:				
January 1908	162	2162	53.56	1.93
Comparison of January 1906 and 1908 shows:				
Increase	23.6	——	——	19.1%
Decrease	——	11.5%	3.08%	——

SAVINGS BY DRY AIR BLAST.

Saving in Limestone through less coke used	$0.05	
Saving of Iron in Flue dust	.04	
Through increased regularity of metal	.05	*
Duration of lining can be increased 30 per cent	.06	
Counting 10 per cent. increased production will reduce cost above material	.10	
	$0.30	per ton.
Saving in Coke—15 per cent	——	†
Value of 10 per cent. increase in output	——	†
Total	$——	

*—In iron used for steel making.

†—Depending on market conditions.

ISABELLA FURNACES—1907

Dry Blast marked with "x"

Month.	Coke per ton iron.			Average daily product.		
	No. 1 fce.	No. 2 fce.	No. 3 fce.	No. 1 fce.	No. 2 fce.	No. 3 fce.
January	2132x	2408	2328	413x	369	369
February	2163x	2500	2353	466x	331	345
March	2206x	2336	2324	465x	378	390†
April	2073x	2281	....	446x	397	...†
May	2029x	2372	....	459x	351	...†
June	2221x	2407	2490	397x	350	313
July	2357	2512	2139x	337	316	374x
August	2472	2625	2046x	343	329	416x
September	2474	2475	2153x	335	343	388x
October	2499	2413	2156x	330	340	392x
November	2403	2438	2367x	305	355	369x*
December	....	....	....	...	...	...
Averages	2136x 2445	2428	2368 2168x	441x 330	351	372 388x

† Lost 4 days—Flood.

* Last figure in column at extreme right "369x" Fdy. Iron.

SUMMARY

No. 1 Furnace { Natural Air Product 330 Coke 2445
Dry Air Product 441 Coke 2136

No. 2 Furnace Natural Air Product 351 Coke 2428

No. 3 Furnace { Natural Air Product 372 Coke 2368
Dry Air Product 388 Coke 2168 1 Mo. Fdy. Iron.

WORK OF DRY AIR BLAST—CARDIFF WORKS, WALES.

	Weekly product.	Coke used per ton of iron.
Average of 50 weeks before dry air was used, (First 50 weeks of blast)	2001 tons	2279 lbs.
Dry Blast running for Increased Output:—		
February 1st	2503 "	1975 "
" 8th	2523 "	1972 "
" 15th	2503 "	1921 "
" 22nd	2649 "	1979 "
Dry Blast Running for Fuel Economy:—		
March 28th	2397 "	1859 "

Advantage of Dry Air for Increased Product—Increase in Output....27.1%
Decrease in Coke.....13.8%
" " " " " Fuel Economy— Increase in Output....19.7%
Decrease in Coke.....18.4%

Period from February 22–March 21—furnace was operated for high silicon iron.

BASIC IRON MADE WITH DRY AIR BLAST E. & G. BROOKE IRON CO.

Date	Dry air blast 1907–8 silicon	Dry air blast 1907–8 sulphur	Natural air 1906–7 sulphur
December 27th	.65	.016	.037
	.75	.021	.030
	.70	.019	.026
	.35	.036	.027
	.36	.060	.025
	.30	.046	.029
December 28th	.45	.033	.030
	.55	.030	.040
	.65	.027	.036
	.50	.018	.037
	.50	.016	.042
	.45	.034	.026
December 29th	.35	.022	.035
	.50	.024	.032
	.65	.021	.032
	.55	.023	.028
	.60	.021	.030
	.35	.023	.053
December 30th	.50	.021	.050
	.80	.019	.048
	.55	.027	.055
	.60	.021	.052
	.50	.015	.037
	.55	.024	.061
December 31st	.50	.019	.050
	.45	.021	.058
	.50	.023	.053
	.60	.021	.037
	.50	.027	.025
	.50	.013	.035
January 1st	.40	.024	.042
	.35	.018	.029
	.35	.034	.046
	.65	.017	.020
	.80	.019	.030
	—	—	.025
January 2nd	.70	.026	.033
	.45	.033	.024
	.50	.028	.021
	.55	.024	.027
	.75	.018	.025
	.50	.013	.020
January 3rd	.40	.019	.022
	.25	.044	.022
	.30	.028	.029
	.45	.027	.032
	.50	.029	.026
	.35	.030	.027
General Average	.51	.024	.035

Attest: JAMES CHRISTIE,
Secretary.

Philadelphia, November 4, 1908.

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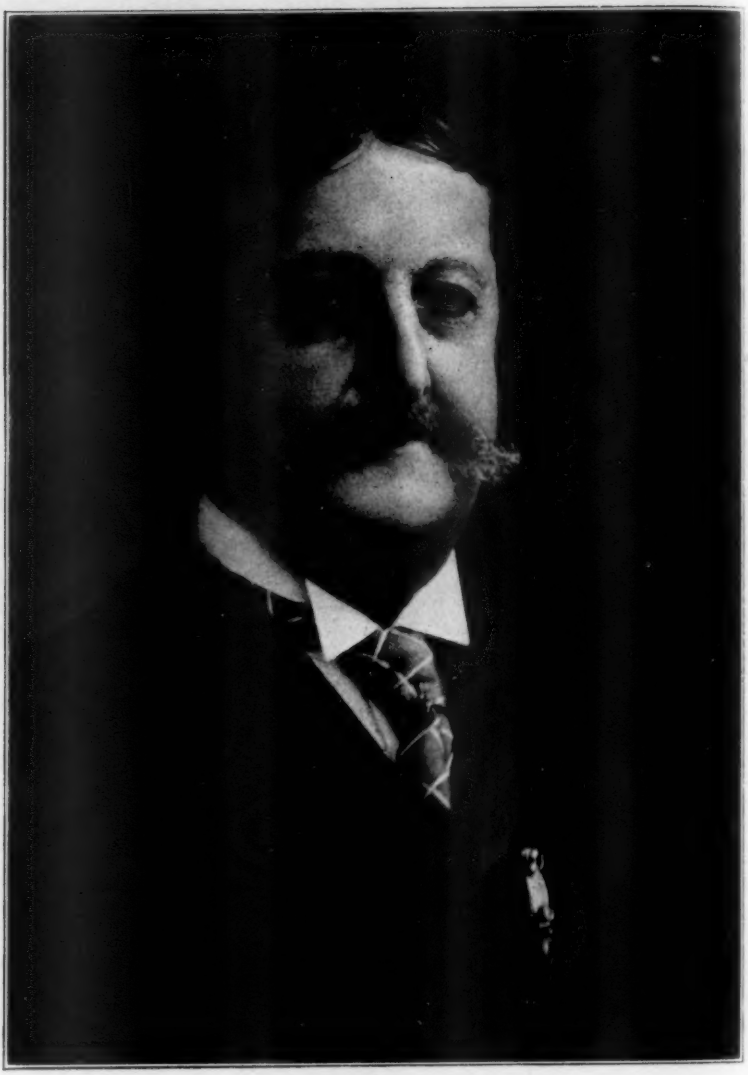

Very truly
Jerry Fraser

PERSIFOR FRAZER, A.B., A.M.,

Docteur és-Sciences Naturelles.

1844–1909.

WITH the passing of Dr. Frazer, the Institute loses the guidance of one of those members whose intellectual attainments and professional achievements have earned for it the recognition and respect of the scientific world. Although deeply engaged in professional pursuits and in scientific investigations resulting in the production of a veritable library of monographs and papers, he found the time and energy to devote himself during many years to the promotion of the Institute's welfare.

His interest in the Institute may be said to have come as a heritage (some of the present-day members can recall the brilliant lectures on Chemistry delivered by his distinguished father, John Fries Frazer). That interest never flagged throughout the long period of his activities. His historical sketch and plea for a better appreciation of the Institute's aims, entitled "The Franklin Institute: Its Services and Deserts," delivered in February, 1908, may be mentioned in testimony of his thoughtful solicitude for the Institute's progress. Again, about his very last act was the editing of a report for the JOURNAL of a comprehensive lecture on the Bertillon System of Identification, delivered some months previously before the Institute, interrupted by his last illness.

It is not merely as a valued contributor in technical and literary work that his loss will be keenly felt. As a member of the Board of Managers he always took an active part and rendered valuable service in the deliberations of that body.

Many men point with just pride to having achieved distinction by their own unaided and unguided efforts. Dr. Frazer was the very antithesis of the self-made man. Behind his distinctions lie a long line of distinguished antecedents, a scholarly atmosphere and unexcelled opportunity to secure a training, the result of which constitutes a monument to his memory.

Persifor Frazer, geologist and chemist, was the fifth generation of the male line of his name in the United States, and was born in Philadelphia, July 24, 1844. He was educated in Phila-

delphia at St. Luke's Parish School by Miss Lucy Learned, at the classical school of Samuel Arthur and at the classical school of Rev. John W. Faires. On July 3, 1862, he was graduated at the University of Pennsylvania with the degree of A.B., and received the degree of A.M. three years later.

The day after graduation he received a commission as Aid in the U. S. Coast Survey, and after a preliminary training of three months, served with distinction in the United States Navy, then in the army and again in the navy from which he received at the conclusion of the war an honorable discharge with the thanks of the Navy Department.

At the close of the Civil War he spent six months in the laboratory of Booth and Garrett studying practical chemistry and in May, 1866, entered the Royal Saxon School of Mines at Freiberg, Germany. He passed the State examination in mineralogy in the German language with as high a standing as was ever granted a foreigner by that institution. Returning in 1869, he joined Hayden's national geological survey party and wrote the report on mineralogy and metallurgy of Colorado and New Mexico in that year.

In 1870 he was elected by the Trustees of the University of Pennsylvania instructor in natural philosophy and chemistry, and the following year promoted to an assistant professorship, both appointments under his father. Upon the sudden death of the latter, October 12, 1872, he assumed entire charge of the department, and a year later the chair being divided into the two professorships of physics and chemistry, he was elected professor of chemistry. In 1874, having succeeded, with others, in inducing the Pennsylvania Legislature to institute the second geological survey of the State, under Professor Lesley, he resigned his professorship and took charge of the survey in York, Adams, Lancaster and Chester counties, contributing four volumes and one monograph to the State reports. During the year 1881 he was General Manager of the iron ore mines of the Central Virginia Iron Company on the Middle James River.

In connection with his researches in the methods of determining authorship and detecting forgeries in handwriting, he invented the colorimeter (for which, in 1896, the City of Philadelphia, on the recommendation of the Franklin Institute, awarded

him the John Scott medal and premium) and discovered the microscopic tremors peculiar to the handwriting of every individual, besides other methods of identification.

It was in this line of endeavor that he was best known in his later years, being frequently called upon in trials before the courts of important cases where the authenticity of signatures was at stake, or when forgery was charged. On these occasions his tenacious adherence to his principles and convictions, his confidence in his mental sincerity and resource and disregard of prevailing beliefs, made him a figure of interest to the public.

While in Paris in 1881–1882 he wrote a French thesis and sustained a public examination before the French Government commission for the degree of Docteur és-Sciences Naturelles, which award was the 196th in all, and the first to one not a native of France, since the establishment of the degree in 1811.

In 1885 he was appointed by the American Association for the Advancement of Science its representative at the inauguration of the Royal Society of Canada and elected Secretary of the American Committee of the International Geological Congress. In 1888 he was elected Vice President of the American Committee representing the United States at the London Congress. The honor of unanimous election to this high office was subsequently awarded to him at the International Geological Congress of St. Petersburg (1897). He was named by the Committee of organization at that of Paris (1900) but was unable to attend.

He was elected Corresponding Member of the New York Academy of Science in 1885, Correspondent of the K. K. Geologische Reichsanstalt in Vienna in 1886, and correspondent of the "Antonio Alzate" Scientific Society in Mexico in 1891. In 1890 he was decorated by the French Government with the golden palms of the Academy and invested with the title of Officer de l'Instruction Publique. In 1897 he was unanimously elected Honorary Member of the Société Geologique de Belgique.

The Franklin Institute chose him Professor of Chemistry and one of its JOURNAL editors in 1882, which position he resigned in 1894, resuming his editorial duties in 1903. During this period he contributed many valuable papers to the JOURNAL and to the lecture course on subjects, in variety, in keeping with his high attainments and versatility. In 1889 he was elected

Professor of Horticultural Chemistry by the Horticultural Society of Pennsylvania.

He was one of the founders and editors of the *American Geologist* and active in many societies, namely: Life Fellow in the American Association for Advancement of Science and in the Geological Society of America (of which latter he was one of the founders); Life Member in the following: American Philosophical Society (Secretary 1896–1898 inclusive), Academy of Natural Sciences, Pennsylvania Historical Society, American Institute of Mining Engineers (Vice President 1880–1881), Pennsylvania Horticultural Society, Franklin Institute, Sociedad Cientifica "Antonio Alzate" (Mexico), British Association for the Advancement of Science, Société Gèographique de Nord (France), K.K. Geologische Reichsanstalt (Austria), Société Géologique de Belgique (Belgium), Military Order of the Loyal Legion, Naval Veteran Association, Cincinnati Society in New Jersey (hereditary member), Pennsylvania Society, Sons of the Revolution and the University Club of Philadelphia. He was a member of the Society of the War of 1812; Society of Colonial Wars in the Commonwealth of Pennsylvania and the Society of American Authors.

Since the conclusion of the Second Geological Survey of Pennsylvania he has practiced as reporting geologist, chemist and mining engineer. He made many reports on the gold, silver, copper, iron, mica, coal, and water in exclusive tracts and private properties, and pursued geological investigations in most of the States of the American Union and Europe.

Among his many publications may be mentioned "Tables for the Determination of Minerals;" "Classification of Coal," four volumes, issued by the Geological Survey of Pennsylvania; Matriculate Catalogue of the College, University of Pennsylvania, from 1749 to 1893; "Bibliotics," or the study of documents, according to Bertillon, "the only scientific treatise on handwriting ever published." His various contributions and papers published by scientific societies number 300.

In 1907 he was elected Vice President of the Council of the American Institute of Mining Engineers and Vice President of the Society of the War of 1812 in the Commonwealth of Pennsylvania.

In private life his accomplishments were as varied as his professional attainment, and there was scarcely any subject in affairs of taste, diversion or literature that he could not treat in a manner both instructive and entertaining. Positive and punctilious to a degree, if he occasionally aroused antagonism, his ever-present spirit of justice and inflexible adherence to truth and precision commanded uniform admiration and respect.

ALFRED C. HARRISON, Chairman,
JAMES CHRISTIE,
LAWRENCE T. PAUL,
} Committee.

THE EFFECT OF BOXING OR BLEEDING SOUTHERN PINES.

"BLEEDING" pine trees for their resin, to which chiefly longleaf (Pinus palustris) and Cuban pine (Pinus heterophylla) are subjected, has generally been regarded as injurious to the timber. It has been claimed that both durability and strength of timber are impaired by this process, and in the specifications of many architects and large consumers, such as railway companies, "bled" timber is excluded.

The utilization of resin is one of the leading industries of the South, and since the process affects several millions of dollars worth of timber every year, special investigations, involving mechanical tests and the physical and chemical analyses of the wood of bled and unbled trees from the same locality, have been carried on by the United States government through the Forest Service.

Results prove conclusively (1) that bled timber is as strong as unbled, if of the same weight; (2) that the weight and shrinkage of the heartwood is not affected by bleeding; (3) that the durability of the heartwood is not affected by bleeding, since the resin comes from sapwood only.

The following table shows the remarkable numerical similarity between the average results for three groups of trees, the higher values of the bled material being readily explained by the difference in weight:

Longleaf pine.	Number of tests.	Specific weight of test pieces. Per cent.	Bending strength per square inch. Pounds.	Compression strength per square inch. Pounds.
Unboxed trees	400	0.74	12,358	7,166
Boxed and recently abandoned	390	.79	12,961	7,813
Boxed and abandoned five years	535	.76	12,586	7,575

The amount of resin in the wood varies greatly, and trees growing side by side differ within very wide limits. Sapwood contains but little resin (1 to 4 per cent.), even in those trees in which the heart wood contains abundance. In the heartwood the resin forms from 5 to 24 per cent. of the dry weight (of which about one-sixth is turpentine), and can not be removed by bleeding, so that its quantity remains unaffected by the process.

Bled timber, then, the tests have shown, is as useful for all purposes as unbled.

FRANKLIN INSTITUTE

(Proceedings of the stated meeting held Wednesday, June 16, 1909.)

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, June 16, 1909.

President WALTON CLARK in the Chair.

Present, forty members and visitors.

Additions to membership since last report, four.

The Chairman introduced Mr. W. H. Fulweiler of Philadelphia, who presented an interesting communication on the "Development of Modern Road Surfaces." The speaker reviewed the progress made in road building, and gave special consideration to the preparation of road surfaces with tar, oil, and other substances. The subject was illustrated with numerous lantern photographs of roads and streets, and apparatus used in the construction and maintenance of modern highways.

A vote of thanks was tendered the speaker and his paper was referred for publication.

JAMES CHRISTIE,
Secretary.

COMMITTEE ON SCIENCE AND THE ARTS

(Abstract from proceedings of the stated meeting held Wednesday, June 2, 1909.)

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, May 5, 1909.

MR. J. Y. MCCONNELL in the Chair.

The following report passed first reading: (No. 2456.) System of briquetting coal—William F. Giles, Philadelphia.

For want of a quorum no action was taken on reports.

The report of the sub-committee on reorganization was presented in its final form, and was ordered to be transmitted to the Board of Managers as the report of the Committee.

BOOK NOTICES

PRINCIPLES OF DIRECT CURRENT, ELECTRICAL ENGINEERING. By James R. Barr, A.M.I.E.E. Lecturer in Electrical Engineering, Heriot-Watt College, Edinburgh. VIII x 551 pages, 6 x 9 inches, with 294 illustrations. Whittaker & Co., London and New York. Price, 10s net.

There is no lack of satisfactory literature on the subject of electrical engineering, and there is consequently no great latitude in the selection of subject matter in the compilation of a course.

The author's aim has been to give a clear and concise account of fundamental principles and whenever possible the methods of applying them by problems systematically arranged in the order of treatment of the subject.

Beginning with an analysis of fundamental units, the subject is developed in logical sequence to cover the applications to the various apparatus employed in the generation, measurement, and distribution of direct currents.

The book is neither too profound nor too elementary for a student who has had reasonable preparation in elementary physics and mathematics, and the frequent numerical examples that occur throughout the work cannot fail to impress the reader with a sense of the reality of the results and confidence in a knowledge of the subject so obtained.

The unstinted collection of diagrams, cuts, and plates and the general typography are of high degree of excellence.

The work as a whole reflects credit both to author and publisher.

L. E. P.

CONSTRUCTION DES INDUITS A COURANT CONTINU—COUSSINETS, PALIERS ET AUTRE ORGANES DE TRANSMISSION. Par E. J. Brunswick et M. Aliamet, Ingenieurs-Electriciens. 192 pages, 4½ x 7½ inches, with 38 illustrations. (Encyclopedie scentifique des Aide-Memoire.) Price, paper, 2 francs 50; cloth, 3 francs. Librarie Gauthier-Villars, Paris, 1908.

This volume is the fifth of a series devoted to a study of the construction of continuous current generation and is devoted exclusively to the topics specified in the title.

It constitutes a convenient compilation of the principles involved in the design of sliding and ball bearings, pedestals, oiling systems and belt transmissions.

Particular reference is made to the Leuveu system of controlling belt tensions, which consists in the application of a tightening pulley carried by a counterweighted arm.

The work concludes with a bibliography and a detailed table of contents.

L. E. P.

ETERAGE, TRÉFELAGE, DRESSAGE DES PRODUITS METALLURGIQUE. Par Georges Soliman, Ingénieur des Arts et Manufactures. (Encyclopedie scientifique des Aides-Memoire.) 164 pages, 4½ x 7½ inches, with 21 illustrations. Price, paper, 2 francs 50; cloth, 3 francs. Gauthier-Villars, Paris.

The author has collected various data on the drawing of metals and their alloys. Following a preliminary consideration of the mechanical properties of the products considered, he describes the operations involved in drawing steel, copper, brass, and bronze, devoting a chapter particularly to wire-drawing.

Briefly, the author has condensed in small compass the best available information relating to the subject.

L. E. P.

LES SUCCÉDANÉS DE LA SOIE. LES SOIES ARTIFICIELLES. Par A. Chaplet, ancien Directeur d'usine et H. Rousset, Ingenieur-Chimiste (Encyclopédie scientifique des Aide-Mémoire). 168 pages 4½ x 7½ inches with 19 illustrations. Paris, Gauthier-Villars. Price, paper 2 fr. 50; cloth 3 fr.

The artificial production of silk by a close imitation of the natural process of the silkworm is one of the triumphs of modern applied chemistry.

In this volume a concise account is given of the discovery of artificial silks, the processes of their manufacture and a description of plant and apparatus employed in the development of the industry. Although somewhat condensed, various processes and their chemical significance and the form elemental apparatus are described in considerable detail. The work is of interest not only to the specialist but to the general reader on technology.

L. E. P.

LES SUCCÉDANÈS DE LA SOIE. LE MERCERISAGE ET LES MACHINES A MERCERISER. Par J. Chaplet, Ancien Directeur d'usine et H. Rousset, Ingenieur-Chimiste. (Encyclopédie scientifique de Aide-Mémoire.) 156 pages 4½ x 7½ inches, 24 illustrations. Price, paper 2 fr. 50; cloth 3 fr. Gauthier-Villars, Paris.

As distinguished from the artificial production of silk the process of mercerization is employed in converting vegetable fibre by a chemical treatment into one closely simulating silk in appearance and physical properties. This work describes in succinct detail the objects of the method, its history and its mode of application and constitutes a companion to the one above noted.

L. E. P.

PUBLICATIONS RECEIVED

U. S. Library of Congress. The Copyright Law of the United States of America in force July 1, 1909. Copyright Office, Bulletin No. 14. 37 pages, 8 vo. Washington, Government Printing Office, 1909.

U. S. Coast and Geodetic Survey. U. S. Magnetic Tables and Magnetic Charts for 1905, by L. A. Bauer, Inspector of Magnetic Work and Chief of Division of Terrestrial Magnetism. 154 pages, maps, quarto. Washington, Government Printing Office, 1908.

Einige Untersuchungen im Staugebiete eines Wasserlaufes bei Brückenbau von W. Plenkner. Sonderabdruck aus der "Österreichischen Wochenschrift für den öffentlichen Baudienst," Heft 1, 1909. 8 pages, plates, folio. Wien, Verfasser, 1909.

Zoölogical Bulletin of the Division of Zoölogy of the Pennsylvania Department of Agriculture. January 1, February 1, March 1, 1909, 3 pamphlets, illustrations, plates, 8 vo. Harrisburg, State Printer, 1909.

Pennsylvania State College Agricultural Experiment Station Bulletin No. 89. Shelter tent experiment with Sumatra-type tobacco. No. 90. Soil fertility. 2 pamphlets, illustrations, 8 vo. State College, 1909.

U. S. Department of Agriculture. Forest Service. Circular 150. Douglas Fir: A Study of the Pacific Coast and Rocky Mountain Forms, by E. H. Frothingham. Circular 155. Production and Consumption of Basket Willows in the United States for 1906 and 1907, by C. D. Mell. 2 pamphlets, illustrations, 8 vo. Washington, Government Printing Office, 1909.

U. S. Coast and Geodetic Survey. Principal Facts of the Earth's Magnetism and Methods of Determining the True Meridian and the Magnetic Declination. (Reprinted from United States Declination Tables and Isogonic Charts for 1902.) 99 pages. Washington, Government Printing Office, 1909.

U. S. Coast and Geodetic Survey. Results of Observations Made at the Magnetic Observatory near Honolulu, Hawaii, 1902–1904, by Daniel L. Hazard. 130 pages, illustrations, 8 vo. Washington, Government Printing Office, 1909.

Photographie de la Comète 1907 d [Daniel]. (I Rapport de l'Observatoire Astronomique des Frères Josef et Jan Fric "Zalov" pres D'Ondrejov—Boheme) par Josef Jan Fric et Fr. Nusl. 3 pages, plates, 8 vo. Prague, Academie des Sciences, 1908.

Première Étude sur les Anomalies de Refraction. (II Rapport de l'Observatoire Astronomique des Frères Josef et Jan Fric "Zalov" pres D'Ondrejov en Boheme) par Fr. Nusl et Josef Jan Fric. 10 pages, illustrations, plates, 8 vo. Prague, Academie des Sciences, 1908.

Carnegie Institution of Washington, Department of Terrestrial Magnetism. Annual Report of the Director, 1908. (Reprinted from Year Book No. 7.) 163–174 pages, plates, 8 vo.

Pennsylvania Medical Society. Messages: Medical Requirements in Pennsylvania; To the Medical Profession; Proposed Medical Bill; Vaccination; Value of Scientific Research. 3 pamphlets, illustrations, 8 vo.

Gas Producers and Gas Firing, and the Advantages of Gas Firing over the Direct Use of Coal. (Reprinted from *The Mining Journal*, February 6, 1909.) By Ernest Schmatolla. 19 pages, illustrations, 8 vo. London, *The Mining Journal.*

University of Illinois *Bulletin*, Vol. VI, No. 4. Chemical and biological survey of the waters of Illinois. Report from September 1, 1906, to December 31, 1907. Edward Bartow, Director. Water Survey Series, No. 6. 88 pages, illustrations, 8 vo. Urbana, University, 1908.

The Machinations of the American Medical Association. An exposure and a warning, by Henry R. Strong. 131 pages, 12 mo. St. Louis, *The National Druggist*, 1909.

U. S. Coast and Geodetic Survey. Results of Observations Made at the Magnetic Observatory at Vieques, Porto Rico, 1903–1904, by Daniel L. Hazard. 70 pages, illustrations, quarto. Washington, Government Printing Office, 1909.

U. S. Coast and Geodetic Survey. Results of Observations Made at the Magnetic Observatory at Sitka, Alaska, 1902–1904, by Daniel L. Hazard. 129 pages, illustrations, plates, quarto. Washington, Government Printing Office, 1909.

Argentine Republic. International Exhibition of Railways and Land Transport to be held at Buenos Aires from May to November, 1910. Programme, Rules and Regulations, Registration and Show Room Fees, Application for Admission, Map of Buenos Aires. 8 vo and quarto. Buenos Aires, The Executive Committee, 1909.

Trigonometrische Längenbestimmung Geodätischer Grundlinien von A. Tichy, Inspektor der K. K. Österreichischen Staatsbahnen. 67 pages, illustrations, plates, 8 vo. Wien, Österreichisher Ingenieur und Architekten-Verein.

Brown & Sharp Manufacturing Co. Catalog of machinery and tools. 549 pages, illustrations, 24 mo. Providence, 1909.

The Munroe Crucible, by Walter O. Snelling. Reprinted from the *Journal of the American Chemical Society*, vol. xxxi, No. 4, April, 1909. 5 pages, 8 vo.

Georgia Geological Survey, Bulletin No. 18. Second report on the clay deposits of Georgia, by Otto Veatch, Assistant State Geologist. 453 pages, illustrations, plates, maps, 8 vo. Atlanta State Printer, 1909.

U. S. Geological Survey. Mineral Resources of the United States. Calendar year 1907. Part I, Metallic Products; Part II, Nonmetallic Products. 2 vols., 8 vo. Washington, Government Printing Office, 1908.

U. S. Commissioner of Education. Report for the year ended June 30, 1908. Volume I, 382 pages, 8 vo. Washington, Government Printing Office, 1908.